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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

MAY 1925

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

Watson Prescribes these Necessities for Easy Riding and Good Roadability

1. *Soft Front Springs (rate in pounds per inch of deflection—around 250 pounds).*

"Bottoming" should be prevented, not by stiffening the Front Springs, but by providing sufficient clearance.

2. *Front Springs should have as few and as long leaves as possible rather than as many and as short leaves as possible.*

Interleaf friction does not help much in preventing "bottoming", but hurts a lot at the start of the spring movement. At static, the coefficient of friction is very high and renders the spring too stiff and stubborn against minor impacts. And that, of course, is just when a spring should be at its softest.

3. *The end of each Spring Leaf should be chamfered to prevent gouging of the next leaf, and all Springs should be well lubricated.*

Well lubricated means oil, not grease.

4. *Rear Springs should be made a little stiffer than is now general practice.*

In conjunction with the above softer Front Springs, this stiffening of the Rear Springs can be done without sacrificing riding quality, and these stiffer Rear Springs will render the car less susceptible to passenger load variations.

In a car so equipped, all impacts and shocks from the lightest to the heaviest will be perfectly absorbed and kept from reaching the body. Watson has always contended that springs are shock absorbers—or should be.

All that now remains for our perfect ride is the matter of adequate control of the rebound force. To be adequate this control must be in *proportion* to the force. Each different extent to which the spring has been compressed means a different force, and therefore naturally calls for a different resistance to control it. This requirement leads us right to Watson Stabilators.

John Warren Watson Company
Twenty-fourth and Locust Streets
Philadelphia
(*Detroit Branch:* 3081-3083 East Grand Blvd.)

WATSON
STABILATORS
The Proper Control for Pliant Springs

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XVI May, 1925 No. 5

Chronicle and Comment

Committee Discusses Sections Affairs

SECTIONS dues and other important problems were discussed on April 16 when the Sections Committee met in Detroit. Inasmuch as no quorum was present at the meeting, it was decided to obtain the opinion of all the members of the Sections Committee through a letter ballot. It is expected that a number of vital questions including the matter of budgets will be acted upon further at the Summer Meeting at White Sulphur Springs in June.

The Tractor Meeting in Chicago

A WIDE variety of topics was discussed at the April 29 and 30 sessions of Tractor Meeting at Chicago in which the Society and the American Society of Agricultural Engineers participated. Members should be interested to read the news account of the sessions that will be found on p. 490 of this issue of THE JOURNAL.

Great credit is due the Tractor Meeting Sub-Committee, O. B. Zimmerman, chairman, that was successful in arranging such an interesting program.

The Service Convention

"SERVICE at a Profit" is the slogan of the second National Automotive Service Convention and Automotive Maintenance Equipment Show that is to be held in Detroit, May 20 to 23. The discussion at the technical sessions will relate to three principal items: men, methods and materials. A very interesting program has been arranged by the National Automobile Chamber of Commerce and the cooperating organizations, and it is anticipated that a large representation of our Society will be desirous of attending both the exposition and the technical sessions. Additional information pertaining to this event will be found on p. 490 of this issue of THE JOURNAL.

What About the Summer Meeting?

THE technical sessions that are scheduled for the Summer Meeting at White Sulphur Springs, W. Va., June 16 to 19, are replete with interest for all whose problems involve the study of one or more of such varied topics as lubrication, fuel utilization, highway safety, riding-qualities, gasoline-electric motorbuses and railcars, brakes, transmissions and noise investigation. Sports events have been arranged to suit the taste of practically everyone, and most desirable prizes will be awarded the winners in the competitions. Further details concerning the Summer Meeting will be found on p. 488 of this issue of THE JOURNAL and in the *Meetings Bulletins*.

Special efforts are to be made this year to give the ladies an unusually good time.

Oil and Gas Power Week

OIL and Gas Power Week, April 20 to 25, was the result of an endeavor to focus nation-wide attention on recent progress and immediate possibilities in the conservation of oil and gas for power purposes. Because of the importance of the fuel question to automotive engineers, the Society was one of the organizations participating in the movement.

To stimulate further interest in this topic, the national committee in charge of Oil and Gas Power Week has announced that a cash prize of $100 will be awarded for the best contribution dealing with the subject of oil and gas power conservation. The contribution may be in the form of a paper presented at one of the meetings throughout the Country, or of a written discussion of a paper, or of an original essay not exceeding 5000 words by anyone who attended any of the oil and gas power meetings. Contributions should be in the hands of the National Committee not later than June 1. Address William E. Bullock, 29 West 39th Street, New York City.

Los Angeles Comes Through

A MOST active informal group of the Society has been maintained in Los Angeles for many months. Profitable papers have been presented and discussed, and much benefit has been derived by members in that locality from regular meetings which have afforded opportunity for social intercourse and the discussion of technical subjects of common interest to engineers. The industrial activities of Southern California are carried on by live companies in which many Society members are prominent, and sources of material are available upon which the meetings of the Los Angeles Group have been founded.

Through the efforts of enthusiastic and loyal members,

this work has been carried on most successfully, and the point has been reached where the formation of a section seems justified. Over 50 active members in the locality have recently petitioned the Council for authorization to establish a regular Section in Los Angeles. It is probable that this petition will be granted and that the Section will be inaugurated sometime in May when President Horning expects to visit California. Much credit is due our members in Los Angeles, especially Ethelbert Favary, of the Moreland Motor Truck Co., who has been particularly active in promoting interest in Society affairs.

Proposed Airplane Tour

At a recent meeting of the Council of the Society discussion was had of the question of holding an Intercity Airplane Tour for civilian contestants, as had been proposed by various persons, conspicuous among these being Col. Paul Henderson, in charge of the Air Mail for the Post Office Department. The matter had also been considered by the National Aeronautic Association for some time. Vice-president Zimmerman and Councilor Warner of the Society attended the sessions of the National Aeronautic Association at the time the program of competitive events for airplanes this year was considered.

It was the view of the Council that the holding of such a tour as had been proposed, similar in a general way to the Glidden Tour, which was inaugurated in the early days of the automobile industry, would be very helpful in furthering aviation in general and commercial flying in particular. The public lacks knowledge and also confidence in too great a degree with respect to the usefulness and reliability of aircraft. The most feasible way of correcting this condition is to hold events such as that under discussion which will familiarize the public in a not too spectacular and even in a casual way with the practical use of airplanes.

Very few are aware of the amount of flying that is done in this Country, particularly by individuals who own and operate airplanes. The number of civilian aircraft that have been flown to aeronautic race-meets in the "on-to" events has been a continual source of surprise. It is stated that over 30 airplanes are privately owned in Detroit and vicinity at this time. The recent consideration given to organizing a private corporation to operate a line of airplanes between New York City and Chicago, and the interest that has been shown recently by Henry and Edsel Ford in aeronautics generally, have brought to the attention of the Country in an emphatic manner the impending development of organized aircraft operation.

Soon after the Council meeting mentioned, a session of aeronautic engineers was held under the auspices of the Society in New York City as related in the April issue of THE JOURNAL, and later a conference was held in Detroit to encourage the holding of an airplane tour this year, the following being present: Col. Paul Henderson, Luther K. Bell, traffic manager of the Air Mail Service; W. B. Mayo, chief engineer of the Ford Motor Co.; C. M. Keys, president of the Curtiss Airplane & Motor Corporation; W. B. Stout, R. W. Schroeder and Vice-Presidents Church and Zimmerman, and General Manager Clarkson of the Society. A committee on ways and means and planning was organized, with the following personnel: H. D. Church, chairman, Carl B. Fritsche, R. W. Schroeder and W. B. Stout.

Considerable interest has been shown in the proposed event by over 50 civilian pilots who have communicated directly with the Society. Further conferences have been held in Detroit recently, these being attended by, in addition to those mentioned above, B. Russell Shaw, executive vice-chairman of the contest committee of the National Aeronautic Association, R. H. Upson and M. P. Rumney. The work of formulating rules under which the proposed tour shall be held is being conducted primarily by the Contest Committee of the National Aeronautic Association. It is understood that the route of the tour will be approximately 1200 miles long. The event would be sanctioned by the National Aeronautic Association and sponsored by suitable organizations in the various localities cooperating with different interested technical bodies.

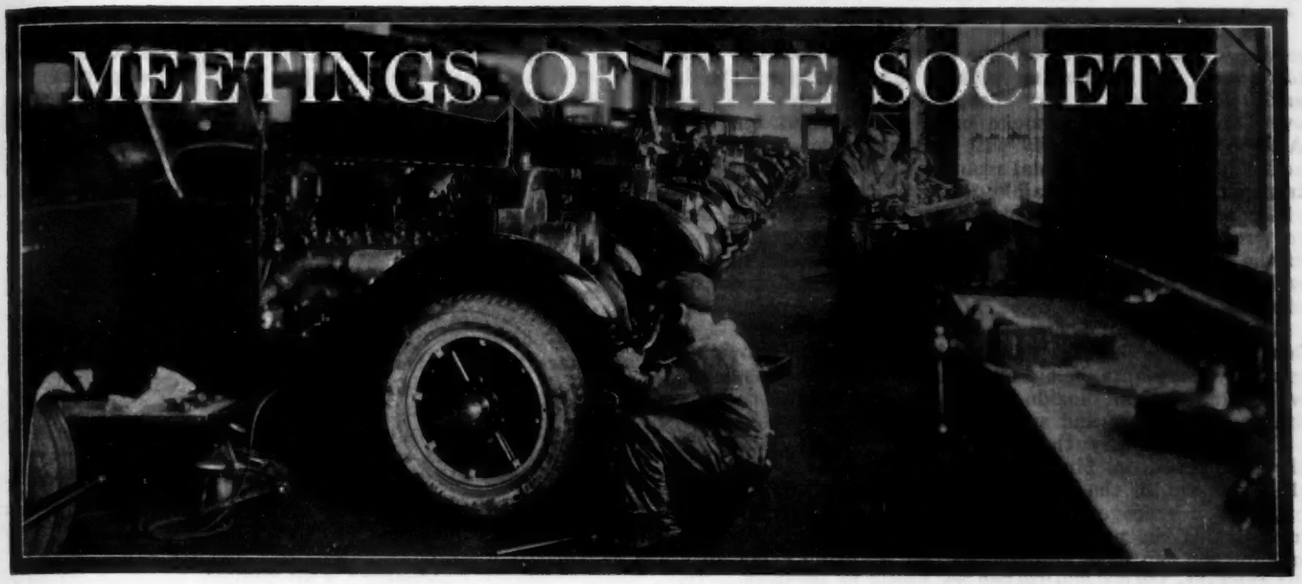
It is planned to have the tour preceded by an on-to-Detroit event, the latter being similar to such competitions that have been held before; all manner of planes being eligible, with starting-points from any region of the Country. It is understood in a tentative way at least that a suitable cash prize will be awarded for each plane which is flown to Detroit from a point 175 miles or more distant. The on-to-Detroit preliminary tour is scheduled to begin on Monday, Aug. 31, and end at Ford Airport, Dearborn, Mich., at midnight Saturday, Sept. 5. On the following day, Sunday, the public will be afforded an opportunity to view the machines.

The date proposed for the beginning of the Intercity Tour is Labor Day, Sept. 7. Suitable regulations as to eligibility for this event, of both airplanes and pilots, will, of course, be formulated. In general, it is proposed that the contestants for the Intercity Tour will be selected on a point basis from those who shall have arrived in Detroit in the "on-to" preliminary. The cities now listed to be included in the tour are: Fort Wayne, Chicago, St. Louis, Indianapolis, Dayton, Columbus and Cleveland, the beginning and end of the tour being Ford Airport. Naturally, the success of the tour will depend largely upon the support in the way of local equipment and facilities and finance given by the various cities through which the tour will go. For this reason the list of cities is necessarily subject to change.

COOPERATION

IF there be one characteristic of civilization which it is most important to grip and hold fast to, I think it can be found in the sentence of Graham Wallas, that the measure of any civilization's progress or status is to be found in its capacity to cooperate.

We have passed, whether we like it or not, out of the age of individualism. We have passed into the age when practically every institution we have is being reexamined to find out how far it invites and how far it facilitates cooperation.—Newton D. Baker.



KETTERING TALKS OF POWER

Tells Detroit Section How Its Increasing Use Has Advanced Civilization

In a vivacious and amusing extemporaneous talk lasting about an hour, C. F. Kettering, president of the General Motors Research Corporation, told a large gathering at the April 2 meeting of the Detroit Section about a wide variety of things, all bearing on the subject of the development and utilization of power. He was in his best speaking vein and kept his audience laughing throughout, although the import of his address was serious.

Prior to introducing the speaker of the evening, Chairman George L. McCain told the members that a special train would be run from Detroit to White Sulphur Springs for the Summer Meeting of the Society, June 16 to 19, picking up special Pullman cars at Cincinnati.

When Mr. Kettering rose to speak, he began by saying that some persons appear to think the world would be a sane place in which to live if it were not for the engineers, who keep changing things; so it might be well if they were dispensed with, which might be done if people could be kept from thinking or if the engineers had already accomplished everything there was to be done in the world. He said he felt that the engineer would lose his job when we have utilized all the forces of Nature to as near 100-per cent efficiency as possible, but that, as we do not know several things yet, it was hard to tell how soon that 100-per cent efficiency would be reached. In the commercial world the greatest difficulty was to get men to use their imaginations. Many think that the automobile of today is perfection, and, of course, being in the industry as we are, it is not necessary to give away any secrets, but he thought some changes would be made as time went on. There are some new forces that we know nothing about. We are just learning to think and to utilize formulas.

Referring to the remarkable rate of development of civilization in this Country, he recalled how every new development, such as the bathtub, steam and electric railroads and automobiles, had been opposed by persons without vision. The great task confronting the engineering world is to have visions of tomorrow and of the future because it is only through visions that we shall be able to keep pace with demands that will be made upon us.

All that engineers and civilization have done, said Mr. Kettering, has been to convert the base materials that are part of the crust of the world into useful articles, and the greater the conversion ability, the more the individual can have. He recalled that Egypt and Rome and Greece reached their highest civilization when they had the largest number of slaves, which increased the productive capacity of those peoples. Our own civilization has kept on growing, notwithstanding the abolition of slavery, because of the development of mechanical horsepower. If the average work capacity of one human being is ⅛ hp. and the mechanical horsepower developed in this Country is roughly 700,000,000, then each man, woman and child has at his command 6 hp., or the equivalent of 48 slaves. We do not recognize the slaves but some bring the water into the house, others bring the light, others carry the messages, and all sorts of slaves are available to relieve the individual of physical labor and discomfort. Having been relieved from the labor and discomfort, we have more time for mental development.

Referring to the discussion of the threat of the increasing population and what will happen when this Country becomes overpopulated, Mr. Kettering said that the population should be about double in the next 35 or 38 years and asked what we will do when the Country has a population of 250,000,000. He drew a comparison with the conditions in India and China. A Chinese coolie, he said, works all day for the equivalent of 10 cents and can move 1 ton 1 mile in a day, but our railroads last year moved 1 ton 1 mile at a cost of ½ cent. On that basis, the coolie is paid 20 times what he is worth.

Any engineering proposition or mechanical device must be economically sound to succeed, the speaker observed, because the public will not pay you more for it than they think it is worth to them. The difference between what the public is willing to pay and the cost of producing an article or service becomes the profit. No man should be fooled into believing that he can set a price on any article, because if the price is more than the public thinks the article is worth they will not buy it.

What are some of the engineering problems confronting the human race? Mr. Kettering inquired. By way of answer, he referred to his recent trip to Europe and North Africa, where he went in search of sources of supply of certain chemicals and other things and observed a number of developments from an engineering standpoint. After narrating some amusing incidents and observations in connection with his trip into Tunis, he spoke at length of the chemical developments in Germany since the end of the war, particularly of the conversion of the high-explosive plants to the manufacture of fertilizers, cow feed and glass that transmits ultraviolet rays. He explained the chemical process by which more ammonium nitrate is being produced from the nitrogen of the air, by the use of coal and water, than is mined in the whole world. They start with coal and water and make water-gas, liberating the hydrogen. Air is liquefied and the nitrogen, which evaporates at a higher temperature than oxygen, is evaporated out. The purified hydrogen and nitrogen are then pumped into large contact-reaction vessels. Ammonia then forms and is tapped off. The speaker illustrated his explanation of the process with blackboard dia-

grams. Coal, water and air are all that are needed to make nitric acid and ammonium nitrate and other products, he said. The process is very cheap. Carbon monoxide is left over, from which they make urea, a wonderful fertilizer. Also, by uniting the urea with formaldehyde and carbolic acid, they form an artificial resin or bakelite of water-white transparency. It is a flexible glass and transmits the ultra-violet rays so essential to plant growth. This glass is used for greenhouses. The urea is also used as a cow food, because of the high percentage of nitrogen in it, the casein in milk, which is the part from which cheese is made, requiring nitrogen.

These elements and compounds with which the chemists are dealing are the same as those with which plants start their growth, the plants being simply machines for converting water and carbon dioxide into a multiplicity of carbohydrates, or starches and sugars.

Explaining briefly the development of heat energy by chemical reactions, Mr. Kettering referred to the effect of the explosion in the internal-combustion engine in uniting oxygen and hydrogen and of the action of the sun and plants in reversing the process, and said that so long as we have sunlight we can have automobiles. If we could catch all of the sunlight, 130,000,000,000,000 hp. would be available. The next great work in scientific development, he thought, would be in chemistry of this sort. When the price of gasoline becomes sufficiently high, we can get all the gasoline we want from shale, and when that is gone we will go back and with the seltzer bottle and a little sunlight we can make alcohol. Many things remain to be done if we keep our imaginations working; we do not know but that we may be able to transmit sunlight from the tropics to the North by radio and run airplanes and dirigibles by radio energy. A great future is ahead of mankind in converting sunlight into useful work.

ENGINE-FUEL-QUALITY DEFINITION

Must Include Adaptability to Prevalent Conditions, Pennsylvania Section Decides

Suitability of present fuels and economic components of the fuel problem occupied the attention of the Pennsylvania Section at the meeting held on April 14 at Kugler's Restaurant in Philadelphia, following an instructive inspection trip made by the members and guests to the plant of the petroleum refining company represented by the speaker of the evening. Some Aspects of the Petroleum Situation was the subject ably presented by John D. Gill, of the Atlantic Refining Co., Philadelphia, who said in part:

> Currently marketed petroleum products are superior to similar products of the petroleum refineries of several years ago, when their technological and economic factors are considered.

In support of this claim, he stated that:

(1) Motor gasolines produce power more efficiently
(2) Kerosenes are safer
(3) Lubricating oils are graded more satisfactorily, the finest grades having been developed to a degree approaching perfection for the lubrication of steam turbines and similar equipment
(4) Transformer oils, in the main, meet the severest requirements of the electrical industry successfully
(5) Gas oils are eminently satisfactory to the artificial-gas industry
(6) Fuel oils are graded better and now fall into well standardized classifications
(7) Paraffin waxes are obtainable within a large range of melting points and of degrees of refinement, even a practically oil-free perfectly white wax having a melting point as high as 140 deg. fahr. being produced
(8) Asphalts for the saturation of roofing and floor-covering felts, for road-block fillers and for road and street construction and maintenance have become well standardized into groups of known usefulness and acceptable to critical engineers
(9) Coke now produced is prepared before shipment so as to overcome the former objections of the electrical industry and provide a product that burns without leaving any ash

Quoting statistics, Mr. Gill said that, from 1910 to 1917, the production of crude oil in this Country increased from 209,000,000 to 335,000,000 bbl. and, from 1917 until 1924, production was doubled, more than 707,000,000 bbl. of crude oil having been produced in 1924. During this period the production of gasoline increased from 14,750,000 bbl. in 1910 to 65,000,000 bbl. in 1917, and the latter production was more than trebled in 1924, when 213,182,958 bbl. was produced. For the 8-year period preceding 1924, while the production of gasoline was being more than trebled, the amount of crude oil run through refinery stills in the process of manufacture was scarcely more than doubled, it having increased from 315,000,000 to 643,000,000 bbl. The present finds the petroleum industry only with comfortable stocks of kerosene, lubricating oils, gas and fuel oils and miscellaneous products.

Quality and Prices

Regarding whether the quality of petroleum products will change, Mr. Gill said that his definition of quality does not mean measurement by arbitrary standards of testing in a laboratory but takes into consideration the utilitarian aspect of the product when compared with the raw material from which it is made. Later, he emphasized that quality is to be measured by the degree of usefulness of the products, considering the raw material available and the economics of the subject; and repeated a former statement that gasolines today are superior in quality on the foregoing basis to those used a few years ago. He believes it to be unfortunate that specifications for petroleum products are sometimes drawn up to suit the chemist's idea of what the product should be, rather than to meet the needs of the equipment that is to use the product.

In reference to the subject of whether the prices of petroleum products will show a variation upward, Mr. Gill asserted that the price record of the petroleum industry is an enviable one, considering that an exhaustible resource is being dealt in and that the products have been improved steadily, and said further that the natural expectation would be for price increases. He quoted the 1913 prices of crude petroleum, its products and other classes of merchandise, given by the United States Bureau of Labor Statistics as a base, and went on to state that from the peak of 1920 through the depression of 1921 and to the present many changes have taken place, but that the general movement has favored the purchaser of petroleum products. He thought the price history for the last 10 to 12 years warranted the assumption that future prices will be conservative and will be low enough to permit the maximum usefulness of the products by the consumer, and that ultimate prices will be subject to the interplay of demand and supply reactions.

As to whether the supply of crude oil will continue to meet the requirements of the industry and those of the individual consumer without restriction, and following a lengthy citation of production statistics and of unmined petroleum resources as estimated by eminent geologists, Mr. Gill pointed out that such resources are in excess of the estimates and believes that new oil-fields, deeper wells and more effective means of production afford some hope that this generation will not be pinched for needed petroleum. He remarked also that great effort had been made in the last several years to organize refinery equipment so that the large quantity of petroleum unfitted in the raw state for other uses than as boiler fuel might be converted into more valuable products and thus conserve the supply. In 1913, it is estimated that 1,000,000 bbl. of manufactured or "cracked" gasoline was produced, and he believes it likely that 75,000,000 bbl. of manufactured gasoline will be produced in 1925; also, that 30,000,000 bbl. of "casinghead" and natural-gas gasoline will be produced this year.

Concerning the subject of whether satisfactory substitutes for petroleum exist, Mr. Gill expressed the opinion that none existed, saying also that no fuel is as satisfactory as gasoline for use in the internal-combustion engine. He understands that the large-scale experiments for producing castor oil to be used as a lubricant have been abandoned and stated that the production of alcohol and benzol together represents less than 3 per cent of our present annual requirement for gasoline. Some engineering advantages and disadvantages of alcohol and of benzol as engine fuels were mentioned.

Should Present Quality Be Changed?

B. B. Bachman, a former president of the Society, and chairman of the meeting, opened the discussion of the subject by saying in part that the answer to whether the present quality of petroleum products is better than formerly depends upon the standard with which such products are measured. If Mr. Gill's statements as to petroleum-product quality referred to the period of about 1918, he agreed with them, but conditions have changed since that time and another sort of standard for measuring petroleum-product quality is needed now. A change in the volatility of internal-combustion-engine fuel has occurred and Mr. Bachman called for discussion on the subject of whether it is to the best interests of the automotive and of the petroleum industries to have the volatility of the fuel unalterable except by the laws of supply and demand, irrespective of season. It appears to him that another step forward needs to be made toward bettering the quality of fuel, interpreting "better quality" to mean making the fuel more nearly suited to the requirements of the apparatus that is to use it.

R. W. A. Brewer agreed that quality should be taken to mean adaptability to prevailing conditions, as applied to fuel. If gasoline is better suited for immediate purposes than were other products in a former age to the purposes of that age, we can say that it is of better quality; but the fuels of today are not comparable with the fuels of a few years ago in Mr. Brewer's opinion, and the fact that as the character of the fuel has changed the engines have been designed to meet the changes explains mainly the reason that present engine performance is possible with fuel of less volatility. An automobile engine built 10 years ago cannot be operated satisfactorily with present-day fuel, he said, because the engine was not designed to use fuel of the present grade. In reply Mr. Gill quoted an advertisement of a large financing company which he said he had seen recently to the effect that 90 per cent of the automobiles produced by a company it had financed since 1914 are still running.

Following further discussion that had to do with economic aspects of the fuel problem and with substitute fuel, Mr. Gill, at Mr. Bachman's request, outlined the major groups of products that are now being obtained from petroleum.

LIGHT ON ENGINE LUBRICATION

Milwaukee Section Told To Get Clean Oil on Piston-Rings and Conduct Heat Away

Better lubrication of an internal-combustion engine by feeding oil under pressure to the cylinder-walls was described by Harry L. Horning, president of the Society and president of the Waukesha Motor Co., at the meeting of the Milwaukee Section held April 1, with G. W. Smith, of the Nash Motors Co., presiding. The speaker showed an enlargement, on a scale of 10 to 1, of a cylinder made by his company in which this system is used. He also showed pictures of a crankshaft bearing with a glass bushing, made by the Standard Oil Co. for demonstrating the flow of oil in the bearing at different engine speeds and the tendency of the oil to follow the journal in its rotation from the low-pressure to the high-pressure area until squeezed out at the sides. Motion pictures of this bearing are to be shown at the Summer Meeting of the Society, he said, and continued:

> I would go across the continent to see them if I had not seen them before. When taking the pictures they fed oil colored with little spots of pigment into the side so that the pictures would show how the oil traveled around. When you see that, it may solve some of your problems, as it did ours. We had a bad problem in the camshaft and, realizing from these pictures that the oil took one direction, we put a groove in the bearing. Then we could pour dirt in and the oil would wash it right out because it would follow the course of the groove.

An interesting demonstration was made with two lubricating oils poured on the edges of an aluminum and a cast semi-steel piston to show how iron or steel causes the oil to spread over the surface while the aluminum causes it to draw up and leaves holes through the oil-film; also, how fatty acids added to a mineral oil overcome this effect.

This demonstration and the explanation of the pictures by Mr. Horning preceded the delivery of his prepared paper on Lubrication. Following the address, he answered many questions on the subject until adjournment of the meeting at 10 p. m.

The Pressure Feed to Cylinder-Wall

The drawing of the piston with the pressure oil-feed near the top showed the oil film on the wall as a thin red line. In explaining the drawing Mr. Horning said:

> You can hardly see that red line with this 10-to-1 enlargement and it does not seem possible that we could run a mechanism that big with that amount of clearance, but that is exactly what we are doing. The joke is that this is quite a little clearance, because we are running it in truck engines where we have to allow still more than you would in passenger-car engines. If it were in a motor-car job, you probably would allow half of that clearance.

This oiling system uses a reciprocating pump that will develop 400 lb. pressure if there is resistance behind it and it delivers 19 drops of oil per 1000 revolutions in a 4½-in. bore cylinder, or ¾ pt. of oil per day in a truck covering from 100 to 125 miles. The oil travels around to the other side of the cylinder by capillary attraction. The feed does not vary with variation of the load. The feeding of fresh oil prevents knocking by providing a seal or oil packing that prevents blow-by of the gases of combustion and so permits the better transfer of heat from the piston to the cylinder-wall, keeping the piston cool so that it does not cause detonation. The engines will run for months and still show the tool marks on the cylinder-walls.

In his explanation of the system from the drawing, Mr. Horning said that all the heat that is absorbed by the top of the piston passes to the sides and seeks a way out, most of it being taken out by the piston-rings. At the surface of the rings there is a dam and the dimension there determines how much heat passes and the rate of transfer. The top ring of an engine is exposed almost to the direct flame of combustion and operates with the full pressure behind it and is subjected to very high temperature. That is one reason, undoubtedly, why carbon piles up behind the ring and why the top ring wears so rapidly in most engines; it is the shock troop put forward to stand the force of the explosion. Besides all the heat that is received by the top of the piston, an enormous amount is generated along the surface of the cylinder-wall and piston-rings due to the shearing stress, he said.

The friction-horsepower loss of an engine goes up to 15 per cent or more of the power developed at 1000 r.p.m. If the losses due to the pump and crankshaft and camshaft bearings are subtracted, it will be found that the loss on the cylinder-wall caused by metal-to-metal contact and by shearing of the oil film is from 0.5 to 0.6 of that amount. About 60 per cent of the friction loss in every one of our engines at 1000 r.p.m., Mr. Horning estimates, is lost in the shearing of the oil-film, and the percentage is vastly more at 2000 r.p.m. That amounts actually to about 10 per cent of the energy of the fuel. Many of our engines are not really giving the drive wheels 10 per cent; they are handling on the cylin-

der-walls the same amount of power that is used to drive the mechanism on the road. All that heat has to be transmitted by the oil-film, mostly through the piston-rings and across the oil-film between them and the cylinder-wall. Of all the influences that wear out our engines, he said, bad carburetion is the worst, because, when the lubricating oil is diluted, the oil-film is thinned and the bearing surfaces come so close together that dirt in the oil spans the gap and scratches the surfaces. If it were not for dilution, which comes from cool oil, we could use much poorer fuel than we are now using.

Glass Bushing Shows Oil Movement

Referring to the bearing with the glass bushing, Mr. Horning explained that when the shaft is revolving a side movement occurs which has the same effect on the oil as the force of gravity has on a falling body; that if the bearing were long enough the pitch of the spiral movement of the oil would grow greater and greater toward the ends and that as the pressure increases the pitch of the spiral goes out but does not go out as the revolutions increase except as the number of revolutions affects the pressure. The oil is forced out very quickly by high pressure, so that, with a narrow bearing, it is important to have tight-fitting sides to hold the oil. As the pressure increases it is increasingly difficult to get oil to the high-pressure areas, but as the rate of revolution increases it becomes easier to draw the oil in. The great damage comes, he said, when the engine is running at low speed and the pressure is high. With a constant pressure, when the journal is slowed down to a low rate of revolution, the whole organization of the flow of lubricant is broken up and the oil-film destroyed, so that there are large spots with no oil on them. Such conditions occur when an engine is started on a cold day, but, with knowledge of how the oil flows in a bearing, it is not impossible to provide against damage that comes at exceedingly slow engine-speed.

Comparing the splash lubrication system with the force-feed system, Mr. Horning said that with the former it was necessary to have a close bearing fit, as the surfaces do not have ready access to the oil and the engine would otherwise be noisy. With the force-feed system, which packs the bearings with oil, the clearances may be much greater, up to 0.005 in. on a 2.000 to 2.500-in. bearing, and still have a quiet engine. Of greater importance is the fact that, after the journal has worn a long time, many ridges are formed in it. These make no difference with the force-feed system, which keeps the surfaces apart so that, even when in exceedingly bad condition, the bearing will run well and quietly, long after it would be necessary, with a splash system, to change or tighten them.

The Usual Order Inverted

The speaker's prepared paper dealt with the objects of lubrication and the attempt to attain them by maintaining an oil-film between bearing surfaces, causes of failure to maintain the film, the generation of heat by overcoming the cohesion of a thick viscous oil, and obstruction to the dissipation of heat from the piston to the cylinder-wall by breaks in the film. The splash and force-feed lubrication systems were discussed and the author observed that with the latter system the problem lay in getting fresh oil to all the surfaces quickly when starting in cool weather. There are records of engines having run 20 min. at high speed without a supply of oil reaching the cylinder-walls. Dilution occurs rapidly during such a period. By far the most difficult part to lubricate is the top ring, which wears four times as fast as the bottom ring of a group of three. The two critical temperature points in the engine that determine the necessary viscosity of the oil are the center of the piston and the top ring. The most logical step is to put the very best oil as near that ring as possible, thus inverting the usual order, in which the oil is fed to the piston from below and carries up dilution and dirt. By feeding fresh oil in at the top, the oil has its maximum viscosity and purity at the top ring and the top of the cylinder-wall, and by feeding definite quantities it can be controlled on a volume basis rather than on a basis of viscosity, clearance and flow. To emphasize this point Mr. Horning said:

> After 2 years' operation on the road we can use the same quantity of oil per mile, and the valves, as well as the cylinder-walls at the top and the rings and pistons, are in a marvelous condition. With fresh oil supplied to the wall, blow-by is reduced to the absolute minimum, and this may account for the success of the system.

Fatty Acids Improve Mineral Oils

Regarding the characteristics of lubricating oils, such as viscosity at high temperature and the ability to stick to surfaces of various materials, he said that for years the oil men have known that lard in mineral oil is of value under certain conditions and that oils are being introduced that have been treated with fatty acids, such as vegetable and animal oils. Such oils have given excellent satisfaction, with few exceptions, in the experience of his company, and seem to be essential when aluminum pistons are used under high loads and on steel surfaces. Friction horsepower is reduced when they are used and in one case an increase of 10 per cent in miles per gallon was secured by adding 3 per cent of lard oil to the lubricating oil.

Replying to questions, Mr. Horning said that to prevent pumping of oil past the piston-ring, he uses a bottom ring that has a groove all the way around and has slots cut out through the grooves on the inside and drills holes into the piston so that the forces of explosion blow the excess oil picked up by the rings to the inside. Although the principle is wrong, and the expedient results in dilution, it is the best way that has been found to take care of the excess. The question of the number of rings to use is determined by several considerations. An added ring decreases the crosshead length and definitely adds to the heat but these disadvantages have to be balanced against the advantage of having two good rings at the bottom when the engines get in bad condition.

Diameter of the cylinder is an important consideration in connection with lubrication, he said. The larger the surface in proportion to volume, the more quickly the heat is radiated.

Asked if he thought the long life of the Rolls-Royce engines was due to adherence by the builders to the system of applying fresh oil to the cylinder-walls, Mr. Horning declared that it was the whole secret of their life. Another point about that engine was that the builder puts in five narrow piston-rings, so that a large surface was always in contact with the cylinder-walls and there was a rapid transfer of heat. He added that all there is to the problem is to get fresh oil on the pistons and rings and enough surface to conduct the heat away.

The discussion also brought out the fact that dilution, in itself, is not an evil. The General Motors Co. advises its users in Canada to put 25 per cent of kerosene in the lubricating oil in winter to make starting easier, and Mr. Horning's own company does the same with users in cold climates. But dilution, together with heat, thins down the oil so that abrasive particles can span the gap of the oil-film and scratch the metal.

It was common to find rust on the cylinder-walls, he said, in response to another question. It was caused by the water vapor of combustion being condensed on the cool walls of the cylinders and oxidizing the iron. High cylinder-wall and crankcase temperatures keep down the formation of rust.

ELECTRICAL RESEARCH-INSTRUMENTS

J. H. Hunt Gives a Very Interesting Talk Before the Indiana Section

The advantageous applying of electricity to apparatus used in automotive research was the theme of a paper given by J. H. Hunt and enthusiastically received by the Indiana Section at its meeting on April 9 at Hotel Severin, Indianapolis. Mr. Hunt's talk was illustrated by slides and was fol-

lowed by a brief discussion and a most interesting demonstration. Substantially the same material was presented as that contained in the paper by J. H. Hunt and G. F. Embshoff, entitled Some New Electrical Instruments for Automotive Research.[1]

After the presentation of the paper, C. A. Trask related an incident that happened some years ago concerning a car which emitted a noise that was difficult to locate. A certain note was produced when the car was running at 16 m.p.h. and a certain higher note at 32 m.p.h. A violinist who was taken to ride in the car recognized the lower note and, when the speedometer got to 32 m.p.h., identified the second note as the octave higher than the first, with twice the number of vibrations of the lower note. The problem was then a matter of locating the noise in the gear teeth by ascertaining how many times a second the teeth passed. Mr. Trask pointed out that Mr. Hunt's electrical device for detecting the sources of noise would have located trouble with less difficulty, because the investigation would have been accompanied by less initial uncertainty.

The following officers were elected for 1925-1926:

Chairman—George T. Briggs
Vice-Chairman—F. F. Chandler
Treasurer—C. A. Trask
Secretary—Raymond F. Buckley

Plans for the May meeting were discussed, a detailed announcement of which will be found in this issue on p. 485.

NITRO-CELLULOSE REFINISHING

New England Section Hears Comprehensive Talk on Interesting Topic

Finishing-material of the pyroxylin type was the subject of a paper presented before the New England Section at its meeting at the Engineers Club, Boston, on April 8. The speaker, who dealt in a most able manner with his topic, was J. J. Riley, manager of automotive refinishing sales, E. I. duPont de Nemours & Co., Parlin, N. J. The product itself was described and contrasted with finishes of the paint and varnish type, and methods of application were discussed with special reference to the use of this type of material for refinishing. The substance of Mr. Riley's remarks is given in the following paragraphs.

The new kind of finish uses a type of nitro-cellulose known as pyroxylin. The basic material is cotton which, after being purified and nitrated, goes through a process to prepare it for the admixture of solvents, gums and the like. The resultant clear liquid is then incorporated with finely ground pigments, and an opaque pyroxylin enamel is thus produced. This type of enamel dries by evaporation and is chemically inert, friction being the only agent that has an appreciable effect on it. It is, of course, affected by its own solvents, alcohol being one of these; consequently, care must be taken to keep anti-freeze solutions containing an excess of 25 per cent of alcohol from splashing or boiling over on a hood that has a pyroxylin finish, as the alcohol will penetrate the finish.

Finishes of the paint and varnish type, it was pointed out, dry chiefly by oxidization and are constantly undergoing chemical changes. For that reason, excessive heat, cold, moisture and the like cause reactions which lessen the life of the finish. As the progressive oxidization goes on, Mr. Riley stated, the finish grows less elastic and more brittle, until it can no longer expand and contract with the metal, and therefore checking, cracking and flaking result; moreover, the actinic rays of the sun attack the varnish and gradually change it into a dull lifeless coat, so that within a relatively short time the finish loses its bright glossy appearance.

Mr. Riley told about test cars with pyroxylin finish that have been in use for more than 2 years, the luster of which was said to have improved with age. The hoods of these test cars have not faded, because the heat of the engine, it was stated, does not affect this type of finish. It is believed that ordinary soaps, gasoline, oils, grease, ammonia, road tar, battery acids, pyrene and even alkaline dust have no effect on the pyroxylin finish. Two of the test cars are in the salt air most of the time, with no evidence that the finish is breaking down. Supplementing these physical-time tests on cars, many exposed-panel tests have been made, both in the North and in the South, one set being in Florida. These panels are periodically examined to ascertain the effect of time on the film; the only ones to show bad effects are those in which lake pigments have been used in the making.

Preparation for Refinishing

In a refinishing job, the stripping of the old finish presents a vital step in the system. After the car has been prepared for stripping, by removing all parts that would in any way interfere with the refinishing, the old paint may be removed in one of three ways: (*a*) paint and varnish removers, (*b*) alkali removers and (*c*) sand blasting.

The use of paint and varnish removers is said to be very effective, provided that a remover having strong penetrating qualities and carrying the minimum of paraffin wax is used. The latter quality is important because of the fact that if any wax is left on the surface it will cause trouble which will be manifested in the non-drying of the pyroxylin coats. This is the only one of the three methods that is applicable to aluminum bodies. Alkali removers are widely used, although great care must be taken to protect portions of the car that the alkali might injure.

After the paint has been removed by either of these two methods, the job must be cleaned and sanded smooth. All moldings and seams should be gone over with a blow torch to remove any foreign matter that may have lodged there. The entire body and wheels should be washed with denatured alcohol, high-test gasoline or turpentine. All evidences of rust should be carefully removed.

The third method of removing the old finish, namely, by sand blasting, calls for the complete taking-down of the car, including the removal of the body from the chassis, and requires a large production to warrant the investment for its installation.

After the job is cleaned and ready for priming, the priming should be done as quickly as possible, as a newly-cleaned job will take on rust very quickly. The priming coat should be reduced to spraying consistency with turpentine, and a light coat should be sprayed on. The primer can be brushed on if so desired, if great care is taken not to apply too heavy a coat. A well-known type of primer requires 24 hr. to dry at a room temperature of 60 deg. fahr. or above.

After the primer has dried, all rough spots such as file and hammer marks in the metal should be brought up with putty glaze. It is recommended that the putty should be dry sanded, as in wet sanding the putty is liable to become water-soaked and show welts. After the application of the surfacer, which is the next step, the finisher must decide if the surface that he has built-up is sufficiently smooth and free from imperfections, as the pyroxylin finish itself will emphasize any marks that may exist in the undercoats. In this connection, some troubles encountered with moldings were discussed.

The application of the finish itself was next described. Where two colors are to be used on a closed body, it is necessary to attach a paper mask around the molding by adhesive tape to protect the top and the body while spraying; window glass should be also covered by attaching masks to the sash with tape. It is often necessary to reduce the finish with equal parts of a thinner. The first coat should be sprayed on very lightly, followed by the second coat in about 30 min. Some operators apply two light coats, one after the other, with satisfaction, although the 30-min. interval is considered a wise precaution. After the first two coats have thoroughly dried, the surface should be examined, after which two more coats can be applied in quick succession. The operator should judge how many coats he needs to complete the job, taking into consideration that he must have an opaque coating that will stand the necessary rubbing

[1] See The Journal, April, 1925, p. 444.

without cutting through to the surfacer and that after rubbing he must have a film capable of withstanding future wear by friction.

The car should then stand overnight at a room temperature of 60 deg. fahr. If the spray work has been good, so that the finish is free from spray waves, pebble effect and the like, only rubbing and polishing with a rubbing compound will be necessary to complete the job. If the spray work has not been satisfactory, rubbing with sand paper and high-test gasoline or with a neutral soap solution will improve the appearance of the finish, after which the rubbing compound should be applied.

In the discussion which followed the paper, Mr. Riley was assisted by Mr. Peterson who is also connected with E. I. duPont de Nemours & Co. The question was asked as to the average time required to apply a pyroxylin finish to a sedan, and Mr. Peterson stated that two first-class workmen should do the job in a day and a quarter. Relative to applying a pyroxylin refinish on a car that had previously been painted, removing paint first, Mr. Peterson said that much would depend upon conditions but that an operator familiar with his work should be able to do such a job in 10 days if allowed to work uninterruptedly.

Mr. Peterson estimated that the cost is approximately the same for a pyroxylin finish as for one of the paint-and-varnish type, although undoubtedly costs vary under different shop conditions and in different parts of the Country. In connection with the factor of cost, the durability of the pyroxylin finish was stressed. The point was brought out in the discussion that nothing in the work of pyroxylin finishing is injurious to health. Medical tests have proved that the application by a spray gun that is used in the work is not injurious to the lungs or to any other part of the body.

Election of Officers

The following officers were elected at the meeting, to hold office for the year 1925-1926:

Chairman—Merl R. Wolfard
Vice-Chairman (Boston)—E. P. Warner
Vice-Chairman (Springfield)—Maurice Olley
Vice-Chairman (New Haven)—E. H. Lockwood
Secretary—W. Laurence LePage
Treasurer—E. O. Wheeler

PRODUCTION AND METALLURGY OF STEEL

Microphotographs Show Metropolitan Section the Causes of Fracture

Copiously illustrated by more than 100 lantern slides, the story of steel was outlined by L. A. Danse, of the Cadillac Motor Car Co., to the members of the Metropolitan Section and their guests at the regular monthly meeting at the Hotel Empire, New York City, on April 16. Comparing iron with water as regards the crystalline structure assumed by each when changing from the liquid into the solid state, Mr. Danse denied that iron crystallizes in service; it crystallizes, he said, when first made, and continues to remain in that condition throughout its life. It may become fatigued in service and its crystaline structure may not be of the right sort to resist the fatigue or vibration that causes fatigue failure, but failure because of crystallization in service is a fallacy. The structure, however, may be altered by mechanical or thermal treatment.

Steel is far from being an element. Even plain carbon-steel is a very complex alloy; it may also contain a half-dozen other metals, metalloids, earthy materials and the like.

Location of ore bodies is no longer left to chance or to a lucky prospector's strike, but is the result of systematic study, prospecting, drilling and charting. With the aid of many slides, Mr. Danse then followed the life history of steel from the time the ore is taken from the mine to the finished state, tracing the various transportation steps, describing the methods of handling, as it passes through the blast, open-hearth and electric furnaces, the molds, soaking pits and rollers, and is finally reduced in section, and sawed into scheduled lengths, and elucidating the various causes of failure in service.

Referring again to the crystalline structure of the metal, attention was called to the fact that this structure by the successive reductions in cross-section and the corresponding elongations, undergoes distortion with a production of flow-lines. Pure metal might not show flow-lines, he said, but no pure metal is marketed.

Instances were cited of disastrous attempts to repair bent parts. In one case, a garage mechanic endeavored to straighten with a wrench a steering-arm that had been damaged in collision. The metal having already been impacted beyond its yield-point was wrenched back beyond its yield-point in the opposite direction, taking a set and producing an incipient crack. A second mechanic instead of trying to straighten a steering-arm cold, decided to heat it. Being of a very high alloy-steel, it had a low range of heating temperature. Not knowing what the correct temperature was, he heated the arm in a forge. It straightened easily but snapped when placed in a car. Practically all factories, Mr. Danse said, advise against repairs of this kind.

Microphotographs Show Defects

A large number of the views shown were microphotographs of cross-sections of steel, magnified under the microscope from 100 to 2000 diameters; as they appeared on the screen the magnification was probably from 150,000 to 200,000 diameters. The effect of the inclusion of impurities was clearly demonstrated.

Several views illustrated the effect of ingotism, that is, a differentiation in the type of crystals that rarely occurs and cannot be accounted for; another view depicted a lime inclusion that had been frozen in the mold in an ingot that was not sheared off sufficiently close in a tonnage mill and had been carried through 50 ft. of the bar until the bar was reduced to forging size. Another slide showed a defective forging-bar in which scratches produced by rough guides in the rolling mill had been welded shut in the rolling process.

Cylinder iron containing graphite causes a cast-iron piston to run smoothly and rapidly, said Mr. Danse. This is because of the graphite abrasive that is imbedded in the metal. It comes out of little holes and rolls over in the oil-film; and the oil-film becomes a lapping film. The graphite smoothes off the little roughnesses in the ferrite. But graphite is an abrasive, not a lubricant, except in the sense that sand is a lubricant on a dance floor, in which case the grains of sand act as rollers under foot. Pearlite, which was defined as a saturated solution of carbon in iron, occurs when the amount of carbon is between 0.85 and 0.90 per cent.

Welding, according to Mr. Danse, is no more encouraged by manufacturers than is straightening. A weld is a casting. Is it sensible, he asked, to unite two forgings with a casting? By so doing, metal is cast into a fracture to replace forged metal that originally was not strong enough. An electric butt weld was said to be the best of all welds with the exception of the new percussion weld, which might be termed a perfected butt weld.

Flow-Lines in Gear Teeth

Examination of the flow-lines of pegged-out flat gears showed that the teeth on one side of the gear, through which the lines flowed lengthwise, were strong; those on the other side, where the flow ran crosswise, were weak. In the upset forging process, the flow-lines carry the fibers in such a way that they go in and out of all teeth in a uniform manner. In the pegged-out flat gears, the teeth in which the flow-lines run lengthwise will withstand from 250 to 260 ft-lb. of energy; those in which the flow-lines run crosswise will withstand only 80 or 90 ft-lb. On the other hand, the teeth of the upset gear will withstand about 225 ft-lb. Although not so strong as the strongest

teeth of the pegged-out flat gear, the teeth of upset gears are immeasurably stronger than the weakest teeth of the pegged-out flat gear. All are uniform and they do not distort so badly in the hardening operation.

A view of the ground surface of a cam, when magnified 100 times, looked like a plowed field. A grinding-machine, said Mr. Danse, is a high-speed milling-cutter having several million teeth. At so terrific a speed, it generates intense heat along the line of contact. In the next thousandth of a second it is cooled instantly by the water running over the grinding-wheel. The line of contact is heated red-hot and quenched immediately. But as steel requires time for physical changes, it cannot stand such abuse and cracks are the result; consequently, it sets, shrinks and pulls apart.

To check-up on bearing metals, an ingenious device called a microcharacter has been invented. It consists of a sapphire ground to the shape of the corner of a cube and mounted in a weighted pivoted arm. When the specimen to be tested is passed under the weighted sapphire, a microscopic scratch is made which varies in width with the hardness of the metal.

Election of Officers

The result of the election of officers of the Section for the ensuing year was announced by Secretary Dutcher as follows:

Chairman—Neil MacCoull
Vice-Chairman—A. F. Masury
Treasurer—S. H. Woods
Secretary—F. K. Glynn

RECENT DIESEL-ENGINE DEVELOPMENTS

Possibilities of Diesel-Engine Usage Expounded to the Chicago Section

What the Diesel engine has done, its possibilities of development and future application to automotive service were major topics of the paper presented by Philip L. Scott, consulting engineer for the Super-Diesel Tractor Corporation, La Porte, Ind., at the meeting of the Chicago Section held on April 17. In addition, motion pictures of the 1924 Semi-Annual Meeting at Spring Lake, N. J., were shown.

Asking what the Diesel engine, when modified for automotive usage, would mean for automotive service, Mr. Scott asserted that it would not only allow the use of cheaper fuel and provide greater fuel economy, but also would give immediate opportunity to use the two-stroke cycle; that is, it would generate about twice the power for an equal weight of engine mechanism, compared with present power attainment. In addition, he said the two-stroke cycle makes possible the elimination, entirely or partially, of valves, and to have the engine exhaust through ports is better in every respect than to exhaust through valves; further that the Diesel-engine principle makes possible the two-stroke-cycle double-acting engine, in which, theoretically, fully three times the power of the present gasoline engine would be available. Considering the effects of its high thermal efficiency, the solid-injection or Diesel engine would cost only one-ninth as much to run as does the present gasoline engine.

Fuel injection provides other advantages, such as the elimination of crankcase-oil dilution and the fact that no fuel is present in the cylinder until the instant of combustion, just enough fuel then being fed continuously to keep the fire going. But, said Mr. Scott, for the present we must consider injection engines as being slightly more expensive than carbureting engines; it is the ultimate use of the two-cycle engine that would make it less expensive than the carbureting engine.

History and Applications

Mr. Scott traced the growth of the Diesel engine in size, giving some of its history and describing some of its applications in conjunction with illustrations. He outlined the status of large Diesel engines in like manner, tracing also the heat flow in these large units, and analyzed high-speed injection-engines. The last mentioned already have broken into the automotive field for use on motor rail-cars and small locomotives. The most striking development of this type is that of the Maybach engine, which runs at 1300 r.p.m. and has a weight of only 18 lb. per b.hp. A gasoline engine for similar use would weigh 15 lb. per b.hp., he said, and used this to substantiate his claim that the Diesel engine has entered the automotive field commercially.

Three classes of service in this Country exist in which the Diesel engine is applicable: self-contained rail-car units of 100 hp. having from 40 to 80-passenger capacity, a "short-haul" unit of about 300 b.hp. and a large locomotive of 1000 hp. or more for freight and passenger service,

SCHEDULE OF SECTIONS MEETINGS

MAY

6—Milwaukee Section—Radiator Cores and Construction—F. M. Young; Steam Cooling—Alexander Herreshoff

7—Detroit Section—Motor Check—R. B. Wasson

12—Pennsylvania Section—Design and Operation of Lighter-than-Air Craft—Lieut-Com. S. M. Krauss; Trip to Naval Air Station, Lakehurst, N. J.

19—Buffalo Section—Possibilities of Hydraulic Steering Control—J. W. White

21—Detroit Section—Development of Automotive Clutches—E. E. Wemp

Metropolitan Section—Fundamental Principles of Automobile Headlighting—H. M. Crane and J. H. Hunt

22—Los Angeles Group—Paper by H. L. Horning

28—San Francisco Group—Rectification versus Filtration of Oil in the Crankcase of an Automobile While in Operation—Herbert L. Dickey

29—Indiana Section—Aircraft for Defense—Major-General Mason M. Patrick; Influence of the Motor Car on the Characteristics of the American People—Hon. Albert J. Beveridge; Address by Charles M. Schwab; The Engineer, What He Has Done for Humanity—C. F. Kettering

Cleveland Section—Annual Local Outing

Chicago Section—No Meeting Scheduled

Dayton Section—No Meeting Scheduled

Washington Section—No Meeting Scheduled

hauling standard-car equipment. Diesel engines have been built for the last two classes but, for the present, the first class has been left to the gasoline engine.

Mr. Scott said that research is being conducted to fit the Diesel type of engine to the power demands of the automobile, the motor truck, the tractor and the airplane. He then described special types of engine that utilize the Diesel principle, such as the Still, a combined oil and steam engine; the Cammelaird-Fullagar double-piston engine; a unique double-acting engine in which the stuffing box is eliminated and others. He remarked, in closing, that he had aimed to present the position the Diesel engine will occupy as a prime mover within the next few years.

Discussion following the paper was informative and interesting but in too great detail for presentation at this time.

INSPECTION OF SHEET STEEL

Topic Exhaustively Discussed at Production Meeting of Detroit Section

Metallurgical analysis of materials is undeveloped; satisfactory methods of physical test remain to be established; the production of sheets that are uniform as regards composition, characteristics and section can be vastly improved; the problems of the steel mill, the stamping room and the paint shop lack definition and coordination. These were among the assertions of F. R. Pleasanton, of the J. W. Murray Mfg. Co., who presented a paper on Sheet Steel Inspection at the Production Meeting of the Detroit Section on April 16. Other papers were presented, one on the surface inspection of sheet metals for the application of a well-known brand of nitro-cellulose lacquer by John McGeorge, of the Oakland Motor Car Co., and another on the testing of sheet steels by E. F. Collins, of the Packard Motor Car Co.

President Horning attended the meeting and delivered one of his characteristically refreshing and inspiring talks.

Important Factors

Mr. Pleasanton introduced his address with a short summary of the principal factors involved in stamping, such as the design of the part and the tools, the material used in the tools and the finish, adjustment and condition of tools when they are employed. As regards the press, the general design, construction, condition and speed were said to be of great consequence. The importance of the proper choice of lubricant, the method of its application and the physical properties and gage tolerance of the material were also treated with relation to their effect upon sheet steel working.

The properties of the material to be stamped are of course among the most vital considerations. High tensile-strength with the yield-point and the ultimate tensile-strength well apart, high impact-resistance, ductility and uniform structure were mentioned among the desired characteristics.

Testing Methods

The equipment available for suitable inspection includes the usual tensile-strength testing-machine; the Rockwell, Brinell and Herbert pendulum machines for hardness determinations; the Olsen ball machine for ductility tests; and the Erichsen machine for impact tests. Inspection testing equipment should be easily and quickly applied and the results should be reasonably dependable.

In his treatment of testing machines and methods, Mr. Pleasanton outlined the advantages and the weaknesses of the various types. Tabulations showing the results of many thousands of tests were explained with the use of slides.

Mr. Pleasanton concluded his very comprehensive paper with a summary of market conditions that require the automotive manufacturer to accept in each shipment of sheet steel up to 15 per cent of "seconds." Careful inspection was said to be vital.

E. F. Collins, of the Packard Motor Car Co., presented a short paper dealing further with the testing of sheet steel. In selecting specimens for test, it has been found that, if the results from three samples taken from each 1000-sheet shipment check reasonably well, the selection may be considered as representative of the lot. The average of test results made on over 300 shipments during recent months was reported as follows: Erichsen, 10.46; Rockwell (B scale), 38.20; Yield-Point 41,800 lb. per sq. in.; Elongation in 2 in., 30.23 per cent; Elastic-tensile ratio, 56.73.

John McGeorge, of the Oakland Motor Car Co., stated that the two prime requirements of sheet steel inspection in view of the use of a well-known nitro-cellulose lacquer for finishing surfaces of automobiles are: (*a*) a perfect surface and (*b*) a perfectly clean surface. He elaborated these two points and concluded that eternal vigilance is the price of cleanliness.

Among those who participated in the discussion were G. E. Conde, of the du Pont Company; John Younger, of *Automotive Abstracts;* and W. C. Peterson, of the Iron and Steel Division of the Society's Standards Committee. Chairman George McCain was in charge of the meeting.

SOME MISSTATEMENTS CORRECTED

In the news account of the February meeting of the New England Section at which Herbert Chase, manager of the research department, *Automotive Industries*, presented a paper dealing with possible improvements in passenger-cars, several unfortunate errors were made. In the first paragraph after the indented matter in the second column on p. 275 of the March issue of THE JOURNAL containing this account, the statement is made that because of the overproduction of cars, the makers are seeking additional selling features, inasmuch as improved manufacturing methods have decreased the cost of production to a point beyond which further reduction is not to be expected.

The reference to overproduction was incorrect, the author stating that "production capacity exceeds present demands." On the subject of improved manufacturing methods Mr. Chase said:

> These methods are certain to undergo further improvement, but the automotive industry is much more advanced in this direction than most other industries already so that there appears to be less chance for commercial advantage through better production methods than through advances in other phases of the industry.

In the first paragraph under the heading "Brake-Linings" in the second column on p. 276, the author was incorrectly quoted regarding the improvements of hand-brakes, his thought being not that hand-brakes have not been improved since they were first installed but that hand-brakes have not been improved so generally or to the same extent as foot-brakes. In referring to the "frameless" cars in the second paragraph of the second column on p. 277, the construction used in the Marmon car was incorrectly described. In this car instead of using the conventional channel frame, the pressed steel web of the frame is carried downward and bent outward to form the running-board and the latter is flanged to give an unusually stiff construction.

AROUND THE WORLD BY AIR

Arnold and Wade Modestly Recount Adventures to Washington Section

From Seattle to Seattle by air westward via Alaska, Japan, India, the European Continent, the British Isles, Iceland, Greenland and the American Continent, a distance of 27,553 miles, covered in 175 days, is the epochal event accomplished by fliers of the United States Air Service, that was vividly pictured before the Washington Section at its meeting on April 24.

President Horning honored the Section by his presence on that occasion and, after being introduced by Chairman Herrington, presented Lieutenants Arnold and Wade.

So much has been written and said concerning this first girdling of the globe by air that the remarkable exploit

of Lieutenants Arnold, Harding, Nelson, Ogden, Smith and Wade are well known to all Americans, who view the accomplishment with considerable pride. To quote Lieut. Leslie P. Arnold and Lieut. Leigh Wade, who told their story to our members in the City of Washington, the completion of this tremendous undertaking was made possible only through the coordination of a number of vital agencies. Others who have endeavored to accomplish the same feat have failed, because of the failure of one or more of the important elements. Complete organization, adequate and satisfactory equipment, well-trained and competent personnel with a will to succeed were all involved in the favorable outcome of the undertaking.

Each of the six divisions of the route was carefully determined, and advance officers were assigned to carry out the organization of each division and base. Spare parts, fuel, lubricants, anchorage and shelter were among the items for which these officers were responsible. The airplanes and other flight equipment were carefully chosen according to their adaptability for the flight, and the personnel were trained to cope with the difficulties of navigation that they were certain to encounter.

The Douglas World Cruisers, equipped with Liberty engines, fully proved their worth, and the personnel, from the fliers to the men in the offices of the Washington organization, successfully carried out the duties to which they were assigned. A more splendid example of the effectiveness of organization, coordination and cooperation could hardly be imagined.

Several interesting items bearing upon the above were brought to light by Lieutenants Arnold and Wade. In Alaska, where Major Martin and Sergeant Harvey were eliminated by an unfortunate combination of circumstances, the greatest hardships and difficulties of the flight were encountered. In this vicinity the winds are so powerful that it becomes necessary to anchor the roofs of houses by cables that are fastened to rock foundations. The weather is seldom suitable for flying and the fliers found it necessary to skirt the coastline at altitudes of less than 20 ft. above the water. From Seattle to Japan the flight did not experience a single clear flying day. In the course of the trip, temperatures ranging from the extreme cold of Alaska to a maximum of 132 deg. fahr. in Persia were endured by the men who were so well chosen for their task.

To illustrate the extreme care and foresight with which the flight was organized, it is interesting to note that tools and spare parts, which were held in readiness at the various stations, were uniformly arranged in such a way that box No. 1, for example, would contain a wrench in the upper right corner, whether found in Alaska or in India. Furthermore, this box was constructed of a good grade of spruce lumber similar to that used in the planes, thus making possible the satisfactory repair or replacement of a fractured member.

As a splendid example of efficient organization, an event

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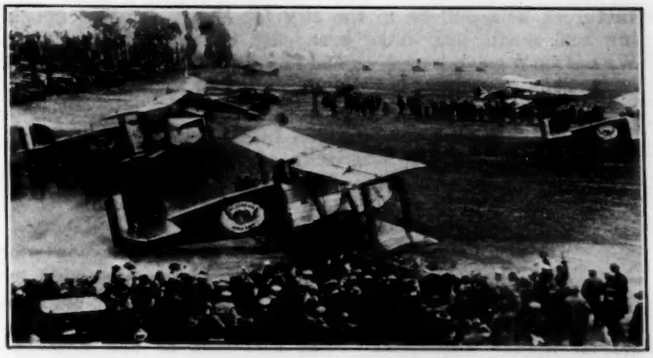
LIEUT. LEIGH WADE



Photograph by Underwood & Underwood

THE START OF THE ROUND-THE-WORLD FLIGHT

When This Photograph, Which Shows a General View of Clover Field, Santa Monica, Cal., Was Taken, the Airplane Piloted by Major F. L. Martin, Which Subsequently Crashed in Alaska, Was Taking-Off

that took place in Indo-China deserves special comment. The engine in one of the airplanes became disabled in a remote part of the country, necessitating its replacement. In only 71 hr. after the machine landed the new engine had been conveyed 500 miles by boat and 100 miles by automobile and had been installed and prepared for flight.

Major-General Mason Patrick, chief of Air Service, summarized the lessons taught by the flight in the following well-chosen words:

> From a military standpoint, this flight has shown that no distances or no difficulties are great enough to make any country immune from attack by aircraft. On the other hand, this same flight has shown how communication between the nations of the world can be improved, how parts of the earth otherwise almost inaccessible or without sufficient means of transportation and communication can be brought nearer, thus enabling men and nations to know each other better, so that aircraft, while potent engines of war, may likewise go far toward bringing about the much desired era of universal peace.

SECTION OFFICERS ELECTED

The tellers reported the election of the following to serve as officers of the Washington Section for the coming year:

Chairman—S. W. Sparrow
Vice-Chairman—Paul Lum
Secretary—Robert F. Kohr
Treasurer—Conrad Young

The members were urged to attend the Summer Meeting of the Society and it was stated that efforts are being made to charter a special car to accommodate those who find it possible to go to White Sulphur Springs.

GREAT EVENT AT INDIANAPOLIS

Dinner Welcoming Memorial Day Race Visitors a Novelty in Industry's Annals

One of the most unusual events in the affairs of the Society and of the automotive industry is being arranged by the Indiana Section as a substitute for its regular monthly meeting in May. On the 29th, the night before the great annual Memorial Day 500-mile automobile race at Indianapolis, the Indiana Section and the Indianapolis Chamber of Commerce will hold a combination welcoming dinner for visiting Society members, which will also be in the nature of a celebration of the twenty-fifth anniversary of the automobile industry and the first anniversary of the commercial aviation industry in America.

Four men of unusual prominence in Government service and in industry are to speak at the dinner and other entertainment features not as yet announced will be staged to make the occasion especially enjoyable and memorable to the racing enthusiasts among the engineers and manu-

facturers who will be in the city for the race. The speaking and music are to be broadcast by radio from station WFBM on a wave length of 268 m. Those who have accepted invitations to address the diners, and their topics, are:

Charles M. Schwab

Hon. Albert J. Beveridge—Influence of the Motor Car on the Characteristics of the American People

Major-General Mason M. Patrick, U. S. A.—Aircraft for Defense

C. F. Kettering—The Engineer, What He Has Done for Humanity

Arrangements for this notable event are being made by George T. Briggs, the newly-elected chairman of the Indiana Section, with assistance of other Section officers and a special dinner committee. The directors of the new Indianapolis Athletic Club have offered the club's large main dining room for the occasion and the local Chamber of Commerce is collaborating to make the affair a huge success.

Among the special guests invited to attend are Henry and Edsel Ford, Charles Clifton, Howard E. Coffin, Harry L. Horning, Edgar Apperson, Gen. Dwight Aultman, Alfred Reeves, Coker F. Clarkson, Samuel A. Miles, Capt. Eddie Rickenbacker, Carl G. Fisher, James A. Allison and James A. Drain. Formal invitations have also been extended to other Sections of the Society and to other guests, in whose honor the dinner is being given, and a large block of seats is being reserved for them. It is expected that covers will be laid for 400 guests. F. E. Moskovics, president of the Stutz Motor Car Co., is to be toastmaster.

Requests by out-of-town Society members for dinner reservations should be sent promptly to George T. Briggs, general sales manager, Wheeler-Schebler Carburetor Co., Indianapolis. Price of the tickets is $3.50. The time and date are 7 p. m., May 29.

Race tickets can be secured by sending a check to Indianapolis Motor Speedway, prices being as follows: $2.50 for grand stand seats, $7.00 for box seats and $10.00 for front-row seats.

NEW YORK CITY'S TRAFFIC PROBLEM

Major Church Explains Metropolitan Transportation Conditions to Buffalo Section

It costs $3.20 to send a barrel of oil from New York City to Seattle by way of the Panama Canal, and it costs $2.00 to get the barrel to the boat. It costs $11 a ton to ship shoes from a certain New England city to New York City, exclusive of railroad charges. These and other equally surprising statements were made by Major Elihu Church, transportation engineer of the Port of New York Authority, at the regular monthly meeting of the Buffalo Section, held at the Hotel Statler on April 7.

In discussing the subject of Freight Transportation, Major Church confined his remarks principally to conditions in and about New York City, which, he said, was a little larger than Buffalo. More tons of freight go in and out of New York City than go in and out of all the rest of the United States. A boat goes in and out of the harbor every 10 min.

A steamship must have adequate accommodations and the cargo must be unloaded. This means that railroad facilities must be provided. Twelve trunk lines terminate in New York City over which about 90 miles of cars arrive a day. As it takes about 5 days before a car will leave the terminal after its arrival, five times 90 or 450 miles of track are filled with cars all the time. The railroads of the Country have more money tied up in terminal property than they have in all the rest of their real estate put together.

Light on Reparation Question

Another fact that shows the magnitude of New York City is that, to make it larger, buildings were torn down last year exceeding in value all the buildings destroyed by the Germans in the first year of the war.

To get freight hauled from the steamship to the railroad and from the railroad to the steamship is the big problem. It costs more to truck it through the city streets than it does to send it across the Atlantic Ocean.

Within a radius of 25 miles of New York City are 105 different communities. New York and New Jersey appointed a commission to investigate conditions and the Port Authority was called upon to put the commission's plans into effect.

Merely acting as a transfer point does not benefit a community; prosperity comes when industry is combined with commerce.

Freight in European Ports

At European ports, boats come in at high tide and are locked in, like our boats in canal locks. Fifteen hundred tons of freight passes over every foot of dock frontage there. New York City has 776 miles of water front within 25 miles of the Statue of Liberty. If we handled 1500 tons per ft. we could get along with 6 miles.

Newtown Creek, a little stream in Long Island flowing into New York Harbor, handles more tonnage than goes up the Mississippi River past New Orleans and St. Louis; more than goes in and out of San Francisco. On the water front of New York City 73 out of every 100 vehicles are drawn by horses. It costs 6 cents a min. to operate a motor truck; horses are not so expensive. The maximum speed of a truck in congested districts is 4 m.p.h. and it only moves 3 hr. per day. At piers on Manhattan Island, observers found the average wait to be 68 min. It took 14 min. to unload. Fifty-four minutes was therefore wasted. At 6 cents per min. this amounts to $3.24.

SPECIAL MOTOR-VEHICLE APPLICATIONS

Dayton Section Is Told How Such Vehicles Further Public-Utility Interests

What a public-service utility company expects of a motor vehicle was outlined forcefully by two speakers at the meeting of the Dayton Section held on April 15. J. F. Casserly, superintendent of supplies and motor vehicles for the Ohio Bell Telephone Co., presented the features specifically related to the telephone business, and O. B. Reemelin, general superintendent of the Dayton Power & Light Co., told of the special requirements in that field. About 70 were in attendance, including local representatives of the telephone and the power companies.

Mr. Casserly said in part that, as exemplified by the practice of the company he represents, the motor-vehicle problem in the telephone industry is one of furnishing transportation for workmen, moving bulky and heavy material and providing labor-saving appliances. His company serves 512,000 telephone stations distributed throughout 40,000 sq. miles of territory, some telephones being located in remote sections and being accessible only over little traveled roads and byways. Telephone toll lines often leave the highways and extend for miles along railroad rights-of-way, cross fields or traverse waste land. Lines must be built and maintained wherever the telephone service penetrates. Construction work usually can be planned to take advantage of good weather and traveling conditions, but maintenance work must be prosecuted and repairs made promptly regardless of weather, of surface and of sub-surface conditions.

A fleet of about 500 motor vehicles is used in Ohio. Most are equipped with special bodies and labor-saving devices. Because of the cost, replacement units are not provided and, as the entire fleet must be in readiness each working day and subject to emergency calls at all times, its maintenance constitutes a real problem.

Many Varied Types of Vehicle Used

After reviewing the history of motor-vehicle usage in the telephone business, illustrating it with lantern slides which he described, Mr. Casserly went on to show and comment upon the different types of vehicle and of labor-saving device in use at present. Among these are light automobiles for loads of from 150 to 750 lb., equipped with special boxes

and specially designed bodies for carrying material and tools. In some instances a light trailer is towed. For installation work, a special body mounted on a ¾ or 1-ton chassis is used.

Heavy construction trucks are used principally in building and maintaining pole lines, stringing wire, pulling underground cable and placing aerial cable. As a winch weighing about 2300 lb. was needed formerly for various purposes, its installation on the vehicle necessitated the use of a 5-ton chassis, but the weight of the winch is now but 500 lb., derricks of ample strength now weigh but 400 lb. and the weight of the body has been reduced to about 2000 lb. with increased load-carrying space provided for cable and messenger-wire reels. Hence, it is now possible to handle the work more satisfactorily with 2 to 2½-ton units than with 3 to 5-ton units. These lighter trucks can travel over roads that would be impassable for heavier vehicles, and their shorter wheelbase makes them more easily maneuverable on narrow roads. Trucks equipped with a derrick for pulling up and resetting poles are used also. Two types of body have been adopted as standard for the heavy trucks. Each heavy truck is equipped with a winch and a derrick.

A cable-reel trailer is towed by a truck when needed. A reel of 1200-pair cable weighs about 2½ tons and Mr. Casserly described how it can be handled by two men, safely, assisted by the winch on the truck and the cable-reel trailer itself. Another device for boring earth, as for pole-hole digging, can be mounted on a truck. It weighs about 2 tons, but can be removed from the truck in say 30 min., thus releasing the vehicle for other uses. The device can average digging 20 to 25 pole holes per day, and can dig in frozen earth. An illustration of this device mounted on a four-wheel-drive truck was shown. On large-sized jobs, a 10-ton drop-frame trailer is used for distributing cable; it can accommodate four reels of cable and the low frame facilitates cable handling. Another special piece of apparatus is obtained by mounting an air compressor on a 1-ton truck. A tractor equipped with a winch is used for pulling cable and towing purposes. Special types of vehicle are used for delivery of supplies and for pay-station collection work.

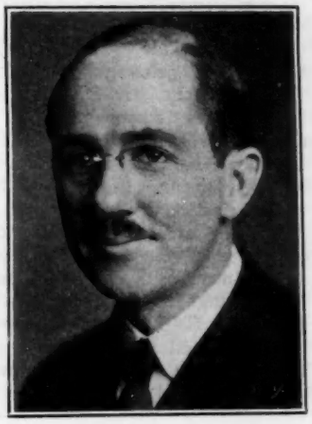
In the garages of the company located in eight Ohio cities, the foreman of each is responsible for repairs to the vehicles within his territory and has both a day and a night shift of employes under his supervision. All these foremen are "working foremen," reporting to the foreman in Cleveland who supervises the maintenance of the entire fleet of vehicles. Minor repairs are made at these garages; complete overhaul work is done in Cleveland or Columbus. Each garage is equipped adequately with special tools and apparatus. Repairs are made on a unit system. Spare engines, axles and parts are kept in stock.

Requirements of a Power and Light Company

Mr. Reemelin remarked that the company he represents looks upon the motor vehicle as a tool and uses it as such. In power and light work, the utilization is similar to that in the telephone business except that heavier material is handled and it is handled higher in the air; for example, the poles average 5 ft. higher than telephone poles. To get the best service from the motor vehicles his company uses, he stated that efforts were made to obtain low costs per mile for operation, for maintenance and for depreciation. First cost of equipment is secondary, compared with the foregoing three items. Low operating-costs result from proper carburetion, a dependable lubrication system, suitable construction that produces a puncture-proof easy-riding tire and adequate maintenance including painting.

Desirable features sought by Mr. Reemelin's company include a carbureter that needs but slight adjustment and that a driver cannot tamper with; a further simplification of the greasing facilities, using fewer fittings and making them more accessible; balance and distribution of vehicle weight; more satisfactory spring design; and greater accessibility of the various units of the vehicle that require frequent attention.

J. F. Casserly



O. B. Reemelin

Except on heavy trucks that need high-pressure pneumatics or solid-rubber tires, all new orders call for balloon tires on cars. Mr. Reemelin said also that his company expects more from the engine of a vehicle than formerly. Power, especially in a territory where hills predominate, is essential. He asserted that his company's fleet was the first to use ethyl gasoline, and that the net result of its use has been the attainment of more power with the minimum of engine troubles such as carbon deposit, spark-plug fouling, oil-pumping, and knocking on hills.

Radiator and cooling-system maintenance is something that Mr. Reemelin hopes can be obviated or lessened. Cold weather causes excessive expense. He looks upon anti-freeze solutions and radiator protective devices as being uneconomical and hopes for less costly and more dependable protection against low temperatures. Ignition failures often necessitate repairs while the vehicle is out on the road and cause excessive delay; he believes ignition trouble to be as great as it was 10 years ago and suggests improvement of the ignition system.

Less vehicle weight and greater strength are also highly desirable in Mr. Reemelin's opinion. To haul a 5-ton load requires a 5-ton unit and, on down the line of carrying capacity, the ratio between the weight of the load and the weight of the vehicle is even more unfavorable.

Points discussed after the presentation of the papers had reference chiefly to details of operation and maintenance.

SIX-WHEEL PNEUMATIC 6-TON TRUCK

E. Favary

At the San Francisco group meeting on April 30, the speaker of the evening at the Hotel Richelieu was Ethelbert Favary, of Los Angeles, whose paper embodied the first description yet given of the new Moreland six-wheel 6-ton chassis fitted with pneumatic tires. No details of this job, which has some interesting new features, are available for publication as yet, as an advance copy of the paper was not received before this issue of The Journal was sent to press. The main portion of Mr. Favary's address was a condensed summary of his paper on Six-Wheel Truck Construction and Operation, which he read at the Los Angeles group meeting last January and which was printed in the April issue of The Journal. In it he discussed the economies and other advantages of distributing the weight of a truck and its load over six wheels.

TRAFFIC CONGESTION AND ITS RELIEF

Street traffic was the subject of a lively discussion at the Los Angeles group meeting on the night of April 24, following the presentation of two highly interesting and informative papers. The first address was given by Dr. Miller McClintock, traffic consultant of the Los Angeles Traffic Commission and formerly of the bureau of municipal research of Harvard University, who spoke on traffic congestion in large cities and suggested remedies therefor. The other paper was delivered by Phil Harris, chief engineer of the Los Angeles Railway Co., whose topic was Can Motorbuses Relieve Traffic Congestion?

The next meeting in Los Angeles is scheduled for May 22, when H. L. Horning, president of the Society, is to be the principal speaker, and it is hoped that by that time the Southern California group of members will be formally organized as a Section of the Society.

PRODUCTION OF CONNECTING-RODS

Manufacturing Processes Used at Six Plants Outlined for Cleveland Section

Those who have believed that the making of a connecting-rod is a simple manufacturing operation having a standardized method of procedure were awakened at the monthly meeting of the Cleveland Section held at the Hotel Hollenden on April 20. The meeting took the form of a symposium in which representatives of six well-known companies in the automotive industry described the methods in use in their respective plants. These methods were as varied and numerous as were the companies.

H. O. Schultz, of the Waukesha Motor Co., was the lead-off speaker. As this company produces a complete line of engines, ranging from small sizes to those of 100 hp., and as the run on any particular size of connecting-rod at any one time is not great, frequent changes of set-up are necessary. To overcome this difficulty, standard machines with special fixtures, simple in design yet effective and economical in production, are employed. These are arranged so that a quick change of set-up may be made and in some cases several different connecting-rods may be operated upon at one time. The complete process comprises 15 operations, which were illustrated with slides.

Special Babbitting Unit

The method in use by the Hupp Motor Car Co. is characterized by a special unit for babbitting, the babbitt being carried, in a ladle of exact size, to the connecting-rod, which is mounted on a spinning wheel, the large end being at the center. When the babbitt is poured, the centrifugal action due to spinning causes the babbitt to impinge homogeneously on the big end.

After babbitting and rough boring, the rods proceed to the vertical drilling machine, which is equipped with a three-arm fixture, one arm doing the drilling, the second the reaming and the third being used for loading or unloading, as the case may be. The capacity is 100 rods per hr.

In the 16 steps in the current practice of the Rollin Motor Co., as described by R. C. Barron, the connecting-rod is always located in the same manner, so that the rod comes through perfectly straight and obviates the possibility of the piston-pin and the crankpin ends not being parallel.

In tinning, the tin must be pure and to get the best results, while the rod is revolving, a wire brush oscillates back and forth, both the rod and the brush being submerged in the tin, which is heated to 700 deg. fahr. The babbitt is applied to the rod in a machine in which the spindle lies horizontal and rotates at a speed of 250 r.p.m. Under centrifugal force, all impurities in the babbitt are carried to the inner surface from which they are eliminated by machining.

No Shims Used in Manufacture or Assembling

The construction of the Chandler connecting-rod, according to Eugene Bouton, differs from that of most other rods in that no shims are used in its manufacture or after its assembling into the engine. When the rods have been machined, a thorough inspection is given them in the rough and any necessary straightening is done. This is more a checking than a straightening operation for the operator receives only 56 cents per 100. In drilling the wristpin hole, the principal locating point is along the crank end of the rod, any variation of the end being taken up in the wristpin hole.

Cleveland connecting-rods are of the type in which the piston-pin is clamped in the rod and the babbitt is cast into the big end. The 15 operations prevailing at present were outlined in detail by N. R. Wells.

In conclusion, John Younger described the process in vogue in the plant of the Chrysler Corporation.

Prior to the beginning of the evening's program, the members of the Section and their guests were entertained by a three-reel motion picture, produced under the supervision of the Bureau of Mines, and showing the complete manufacturing process of a Continental engine. Each of the speakers in the symposium also illustrated his talk with numerous lantern slides.

BACK TO WHITE SULPHUR SPRINGS!

Plans for Summer Meeting at Popular Resort Take Definite Form

In answer to the oft-repeated query "When do we go back to White Sulphur Springs?" the Meetings Committee has practically completed the final plans for sessions and events of the Summer Meeting, June 16 to 19, at that delightful meeting-place. Within a few days members will receive the first of the *Meetings Bulletins* in which detailed information pertaining to the meeting will appear. Application blanks for hotel reservations will accompany the bulletin.

From the opening luncheon on Tuesday until the closing event on Friday, things will be happening at White Sulphur. Relaxation, recreation and education are words that epitomize the principal objectives of the gathering. Sports events of all kinds are being organized, and a group of technical sessions of outstanding merit have been arranged. A number of Sections will present stunts that will recall some of the good times that have always been features of our Summer Meetings.

Special efforts will be made to provide pleasing diversion and entertainment for the ladies who attend. Their presence is greatly to be desired, and they are assured of a most happy visit.

The Technical Sessions

Opportunity will be afforded by the technical sessions for the discussion of transmissions, fuel utilization, lubrication, brakes, gasoline-electric motorbuses and rail-cars, highway safety and research matters including the investigation of riding-qualities and noise. As usual the semi-annual business meeting, a meeting of the Standards Committee and sessions of various other committees will be held.

Certain details of the technical sessions may be of interest. Engineering information pertaining to rail-cars, with especial reference to the application of the gasoline-electric drive, will be discussed by C. O. Guernsey of the J. G. Brill Co. H. S. Baldwin, of the General Electric Co., will give interesting details concerning applications of the gasoline-electric drive to motorbuses.

O. M. Burkhardt, manager of the Society's Research Department, will deliver a paper on the theory of braking, whereas a paper by John Cautley and A. Y. Dodge, of the Bendix Brake Co., will cover the engineering phases of mechanical types of brake, servo-mechanisms and self-energizing features. A representative of the hydraulic brake field will be present to tell his story, and an opportunity will be afforded for the open discussion of the brake situation in general.

D. P. Barnard, 4th, of the Standard Oil Co. of Indiana, will be on hand to present the results of his investigation of

NATIONAL MEETINGS CALENDAR

AUTOMOTIVE SERVICE CONVENTION AND MAINTENANCE EQUIPMENT SHOW
Detroit—May 20-23

SUMMER MEETING
White Sulphur Springs, W. Va.—June 16-19

MOTORBOAT MEETING

PRODUCTION MEETING AND EXHIBITION
Cleveland—Sept. 15 and 16

AUTOMOTIVE TRANSPORTATION MEETING
Philadelphia—September

AERONAUTIC MEETING

SERVICE ENGINEERING MEETING
November

ANNUAL DINNER
New York City—Jan. 14, 1926

ANNUAL MEETING
Detroit—January, 1926

the mechanism of lubrication. Cylinder-lubrication research will be discussed by A. Ludlow Clayden, of the Sun Oil Co. Neil MacCoull, of the Texas Co., will speak of recent results of his investigation of lubrication factors. A representative of the Bureau of Standards is scheduled to deliver a report covering recent developments in fuel utilization and lubrication that have come from the Co-operative Fuel Research.

P. M. Heldt, engineering editor of *Automotive Industries*, has well under way a splendid paper on transmissions. Fundamental factors related to the transmission problem will be discussed by other able engineers, and a wealth of interesting material will undoubtedly be presented.

The investigation of noise phenomena will be outlined by H. C. Snook, of the Bell Telephone Laboratories, Inc., who will give an elaborate demonstration of apparatus pertaining to the topic. F. C. Mock, of the Stromberg Motor Devices Co., Inc., will speak of the dynamics of spring suspensions, whereas R. W. Brown, of the Firestone Tire and Rubber Co., will tell of his research on riding-qualities and the development of suitable apparatus, methods and technique. A session of vital interest to all who are concerned with automotive research is anticipated.

AFTERNOON TEA ON THE VERANDA
Attractive Features Will Be Arranged for the Ladies

Dr. H. C. Dickinson, of the Bureau of Standards, will have a paper devoted to driving rules at the Highway Safety Session. Secretary of Commerce Hoover has promised to send an able representative to present his views on the subject of highway safety as interpreted by the report of the recent conference.

Exhibitions and demonstrations of apparatus and equipment will be important features of all sessions. The Meetings Committee will not approve or permit the display of equipment not directly pertaining to the topics under discussion, nor will it, under any circumstances, tolerate commercial solicitation on the part of anyone during the period of the meeting.

REDUCED RAILROAD RATES

Arrangements have been made with the railroads whereby members may purchase round-trip tickets for fare and a half. This privilege is limited to members of the Society and their families. Special cars and trains operating on convenient schedules will be provided for the accommodation of members coming from or through the various centers. Additional details concerning these provisions will appear in the *Meetings Bulletins* and in the June issue of THE JOURNAL.

BRING THE CAR!

For those who wish to drive to White Sulphur Springs, information regarding preferred routes is being obtained by the American Automobile Association. This will be published in due course. White Sulphur, with its lovely scenery, offers ample reasons for bringing the car as countless drives of great beauty and interest are to be found in the neighborhood.

SERVICE CONVENTION AND SHOW DETAILS

Interesting Features Planned for Meeting in Detroit, May 20 to 23

A better program and a larger show, surpassing even the successful meeting of last spring, are promised for the second Automotive Service Convention and Maintenance Equipment Show that will convene in Detroit at the General Motors Building on Wednesday, May 20. The Convention will hold sessions on Wednesday, Thursday and Friday afternoons, and the Show will be open on those days from 10 a. m. to 2 p. m. and from 5 p. m. to 10 p. m., as well as on Saturday, the 23rd, from 10 a. m. to 6 p. m.

The keynote of the Convention is expressed in the words, "Service at a Profit," and the many interesting items found on the program prove the slogan to be well-chosen. Alvan Macauley, chairman of the National Automobile Chamber of Commerce Service Committee, will be the presiding officer at the opening session, May 20 at 2 p. m., at which time he will define the purpose of the meeting. At this session, Howard A. Coffin, of the Cadillac Motor Car Co., will discuss The Personal Equation in Service Profits; J. E. Mills, of the Packard Detroit Branch, will talk about Service-Station Management; and Robert C. McWane, of the National Motor Regrinders and Rebuilders Association, will present material on Engine Reconditioning—Grinding, Honing, Boring.

E. V. Rickenbacker, of the Rickenbacker Motor Co., who will be chairman of the second session, scheduled for May 21 at 2 p. m., will discuss the topic, The Place of Service in the Industry. At that session Methods of Selling Service will be treated by a prominent dealer who has made a conspicuous success of service, and William G. Gow of the Studebaker Sales Co. will tell about Making a Success of Flat-Rate and Piece Work.

C. E. Gambill, president of the National Automobile Dealers Association, will be chairman of the session that will convene at 2 o'clock on the afternoon of the 22nd. Mr. Gambill will discuss the subject, Making the Service Department Pay. J. F. McDonald, of Ohio Buick Co., will tell about Training Repair-Shop Personnel; and L. C. Hill, of Valentine & Co., speaking on the topic, Why Paint Is Greatest Aid to Selling Used Cars, will give a demonstration in connection with his talk.

A general invitation to attend is extended to all who are in the service business, including factory service-managers and engineers, distributers and dealers and their service-managers, shop superintendents, proprietors and mechanical men from garages and independent repair shops and electrical, tire, battery and other kinds of service-stations, as well as service-managers for fleet owners.

TRACTOR MEETING A BIG SUCCESS

Agricultural and Automotive Engineers Discuss Problems of Common Interest

Tractor lugs, the power take-off, production methods and equipment, belt speeds, spring design, lubrication, fuel utilization, ignition and research were among the topics of broad timely interest that were ably discussed at the Tractor Meeting held at the Great Northern Hotel, Chicago, April 29 and 30. The American Society of Agricultural Engineers and the Society of Automotive Engineers cooperated in this successful undertaking. F. A. Wirt and O. B. Zimmerman acted as chairmen of the agricultural and automotive sessions sessions respectively.

On each day of the meeting the members and guests lunched together and listened to interesting speakers. On the 29th Herr Otto Philipp, director of the Institute for Agricultural Machinery, Landsberg, Germany, spoke on agricultural machinery engineering, development and research in Germany. He mentioned especially the work on soil milling machines. On the 30th A. W. Fitzpatrick, of the Hart-Parr Co. recalled many incidents pertaining to the early days of the tractor industry that were at once interesting and amusing. President Horning, when called upon by Toastmaster Zimmerman, gave an inspiring address in which he made a plea for diversification of interests in the tractor industry.

On the evening of the 29th members of the cooperating societies enjoyed viewing a number of reels of motion pictures showing the production and application of tractors of various types. These pictures and those exhibited at the afternoon session of the 30th were courteously loaned by the International Harvester Co., Advance Rumely Co., J. I. Case Threshing Machine Co., Holt Mfg. Co. and Ford Motor Co.

Tractor Wheel-Lugs Tested

An ingenious arrangement for testing the efficiency of tractor wheel-lugs, described by Prof. E. V. Collins, of Iowa State College, has for its purpose the segregation and the determination of the various factors involved in the operation of the tractor wheel. The arrangement consists essentially of a single tractor wheel mounted in a frame behind the tractor and driven in such a way that it tends to pull the tractor backward. The connection between the tractor and the test-wheel frame is through a recording dynamometer; the test-wheel, mounted on ball-bearings on its shaft, is driven by a hydraulic cylinder and piston mounted on arms connected to the shaft and the wheel respectively. The hydraulic pressure developed in the cylinder is transmitted through a tube to the recording mechanism in such a way as to make possible the calculation of the work input. The rotation of the wheel is determined by the use of an electrical contact device. The test-wheel can be variously equipped and the efficiencies, rolling resistances and other factors can be easily determined from the records of pressure and dynamometer pull as above noted.

Tractor Research

Further research work is urgently needed, said Prof. O. W. Sjogren, of the University of Nebraska, who stated that the highest efficiency and the least slippage are obtained with tractors of the 4500-lb. class. Most of these are in the 10-20 class. Why cannot the same efficiency be obtained with other weights was one of the points he raised, others being what are the requirements of high efficiency, the average weight of tractor corresponding to a given drawbar pull, the most efficient weight of tractor per inch of rim width and the most efficient belt speed? In his opinion fuel consumption, power transmission, governors, air-cleaners and the adaptation of tractors to row crops also demand attention.

The importance of adequate lubrication and of securing the proper kind of oil was emphasized by Chairman O. B. Zimmerman.

W. W. Nichols referred to the willingness of agricultural colleges to cooperate. In this H. B. Walker concurred, adding that what is needed is a carefully outlined plan so that the various research problems can be assigned to those most capable of handling them. Most of the money available at agricultural colleges is spent on the study of crops and very little on farm machinery research, he said.

Assistance of Institutions

The work of state institutions is well known, said H. E. McCray. The tests at Lincoln, Neb., and in California had proved very valuable to the industry. The minimum weight of tractor per horsepower that can be successfully used, the maximum power that the axle can transmit for a given weight of tractor and comparative tests under the soil conditions of different states were suggested as subjects of additional inquiry.

As every farm has plenty of material that could be used in the production of denatured alcohol, Chairman Zimmerman considered it important that farmers should be educated in producing it for operating farm equipment.

Farm management and methods of determining costs were stressed by H. P. Clausen.

Power Take-Off Discussed

Power take-off devices were discussed by F. N. G. Kranich, of the Timken Roller Bearing Co. In certain of these devices the speed is a function of the engine speed; in others, of the rate of travel of the tractor. Lack of uniformity in the percentage of the engine power supplied to them, and in the method and location of the power take-off was said to handicap its more general use. Determination of basic requirements and cooperation with tractor builders, said Mr. Kranich, are essential for the proper development of the take-off. Consideration should be given, he believed, to (*a*) standard speeds; (*b*) standard forms of attachment; (*c*) location of the take-off shaft; (*d*) location of the slip-joint, whether on the drive-shaft or tractor, and (*e*) the percentage of power to be transmitted by it.

Tractor Belt-Speeds

A range of more than 2 to 1 at present prevails in the belt velocity of tractors, some being designed to run at 4100 ft. per min., whereas others operate at 1900. In a paper on Universal Belt Speed for Tractors, L. H. Letz, of the Letz Mfg. Co., stated that a variation of 100 or 200 ft. per min. should include all tractors having from 10 to 40 hp. and recommended that a standard speed of from 2500 to 2700 ft. per min. be adopted. Replies to a questionnaire sent out by him to manufacturers were unanimous in their approval of this specification. In suggesting points that should be borne in mind in the design of tractors, Mr. Letz advocated the following: (*a*) a general normal belt velocity, (*b*) a strong belt, (*c*) pulleys mounted on strong rigid shafts, (*d*) ample bearing-area or anti-friction bearings, (*e*) greater width of belt with increased power, (*f*) belts with good tractive surfaces and high-tensile strength and (*g*) one belt velocity for all tractors that deliver from 10 to 40 hp.

Chairman John Mainland of the American Society of Agricultural Engineers Committee on Belting, in submitting the Committee's report stated that only main-drive belting had been considered. In general, he said, the S.A.E. Standards have been adopted, the main difference being in the 9-in., five-ply type, the length of which has been placed at 150 instead of 160 ft. It was recommended that all main-drive belts should be of the full specified length, that the limit of allowable stretch should be 2 per cent, and that after use such a belt should return to its original length. Four-ply belts should not be used with pulleys less than 7 in. in diameter, nor five-ply belts with pulleys less than 11 in. in diameter.

The papers hereinbefore mentioned were included in the portion of the program for which the American Society of Agricultural Engineers was responsible. The following items were presented on the 30th at the sessions sponsored by the Society of Automotive Engineers.

Tractor Ignition

L. F. Burger, of the International Harvester Co., reviewed the development of tractor ignition-systems and called attention to the obstacles that have been encountered. Beginning with battery ignition, the improvements led first to rather crude and cumbersome magnetos of the low-tension type with make-and-break igniters, then to small high-tension magnetos equipped with the impulse starter. The efforts of manufacturers to produce magnetos to withstand the hard usage and adverse conditions under which tractor jobs operate has proved advantageous to the types used on passenger cars, motor trucks and motorbuses. As regards spark-plugs, Mr. Burger stated that with improvements in tractor engine design, especially in the cooling systems, it has become possible to use standard spark-plugs, usually the ⅞-in. S.A.E. Standard type.

Oil Cooling Advocated

G. W. Iverson, of the Advance Rumely Co., called attention to the fact that with oil instead of water as the cooling medium danger of freezing was avoided as was also the likelihood of clogging and corrosion. Overheating was said to have been eliminated and more efficient operation realized. One advantage attributed to the arrangement described by Mr. Iverson is that the cooling automatically increases as the load increases. A pump is required for positive circulation when oil is employed; thermosiphon systems of oil cooling were said to be unsatisfactory. The speaker called attention to the fact that his company is the only one that builds oil-cooled tractors. The construction cost is greater, he said, chiefly on account of the larger size of radiator required, but this disadvantage of greater cost is more than offset by the increased satisfaction of the user. In the discussion that followed Mr. Iverson's presentation several members recounted their experiences in operating automobiles with oil instead of water as the cooling medium. It was generally agreed that for best success under all conditions the oil-using installations should be specially designed for the purpose.

Fuel Utilization Topics

Carburetion and manifold requirements for the satisfactory burning of kerosene in tractor engines were outlined by H. F. Bryan of Ensign Carburetor Co. in a very interesting paper that reviewed the progress that has been made since the earliest days of the industry. Different methods of heat application and vaporization were described, and mention was made of the water-injection method of detonation control. Mr. Bryan dwelt upon the necessity for accurate metering, proper vaporization and suitably designed induction systems ensuring efficient distribution. Based on the great advances that the last few years have witnessed, he predicted that the future will bring phenomenal progress in fuel utilization.

A representative of the Holley Carburetor Co. used a cutout model in describing the features of the hot-plate vaporizer developed by his company for use on Fordson tractors. The Kingston Regenerator for Fordsons was described by a representative of the Kingston Co.

Production Methods and Equipment

In a paper of peculiar interest to production men, Max Sklovsky, of the John Deere Co., briefly traced the development of tractors from the time when they weighed from 20,000 to 30,000 lb. up to the present time when the lighter weights predominate. The weight per plow-bottom was said to have been reduced from 3000 to 1300 lb. The speaker advocated the adoption by tractor companies of automotive production practices and believed that much might be gained by the employment of line-production methods. The important points of the paper may be briefly summarized. A tendency exists to increase production costs by the adoption of close material specifications, by the multiplication of machining operations, by greater precision in manufacture, by the extension of heat-treating operations and by the addition of heavy-duty equipment. On the other hand, these extra efforts in production are offset by the effects of more rapid production, by departmentized methods that simplify operations, by the reduction of the time required for setting up, by the elimination of the necessity for fitting in assembly, by decreasing the amount of material handled, by the reduction of process inventory, by the simplification of supervision, by the elimination of confusion, by the ready ability to hold to schedules and by a quick turnover of raw materials. All these factors tend to lower the cost of production and to bring about a marked gain in productive capacity. The quality and the uniformity of the product are also improved. In conclusion, Mr. Sklovsky stated his conviction that manufacturers who overlook recent developments in methods of production and equipment are placing themselves in a dangerous competitive position.

President Horning on Engine Research

After reviewing briefly the history of the tractor industry and summarizing the economic factors that pertain to the farmer's situation President Horning stated that it is encouraging to know that designs are no longer prepared "with stub-pencils on the backs of flour bags by the 'thumb on the scale held at arm's length method.'" He regretted that

executives in general fail to realize the real value of practical research, but predicted that within the next 10 years we shall see the value of several pieces of commercial development and intense research in the tractor field that will establish the industry on a very permanent footing and make it possible for farmers to realize a reasonable return in service and saving in production costs from their investment. He believed that all tractor design, all research and all production should be based upon this economic factor. In view of his obstacles and problems, the farmer should be classed as the peer of optimists, he felt.

Turning to the general problem of research, President Horning expressed the conviction that the time devoted to research projects is often improperly divided and applied. By giving more time and thought to a careful first analysis and study of the problem the total time could in most cases be made much less than that required when only a relatively short analysis is made.

Fuel characteristics, lubrication and engine speed were mentioned as important factors influencing first, upkeep and operation costs. In consideration of the mechanism of combustion, the practical advantages and limitations of various fuels and the economic factors involved, it was felt that no economy is effected in burning kerosene in tractor engines when the kerosene price is within 7 cents per gal. of that of gasoline. The wear of pistons, cylinders, piston-rings and other parts and the reduced performance were said to more than offset the apparent saving. With reference to this question, President Horning believed that the tendency should be toward the more extensive use of gasoline and that even on a price-per-gallon basis kerosene will not be in competition with gasoline within 5 years' time.

Attention was directed to the fact that the much discussed top ring which receives the severest punishment from a heat standpoint is also at a great disadvantage from the standpoint of lubrication. In the first place the oil starts from below in a contaminated condition that greatly detracts from its ability to lubricate properly. As it progresses toward the top of the cylinder and the piston the situation becomes aggravated until the point of greatest need is reached at a time when the degree of suitability is least. This situation has led to the revival of the old system of feeding a definite and adequate quantity of fresh, clean oil to the cylinder-walls while using the overflow that drips into the crankcase to lubricate the crankshaft, camshaft and other bearings. With this arrangement the character of the lubrication more nearly meets the requirements.

President Horning stated that the Cooperative Fuel Research, in which the Society has participated, has shown that (*a*) the temperature of the oil in the sump determines the amount of dilution, (*b*) the temperature of the cooling water should be as near boiling as possible to keep dilution low and (*c*) when the cylinder-walls are kept at the temperature of boiling water vaporization is promoted and widely different temperatures of the atmosphere make little difference in the running of the engine.

With reference to engine speed it was stated that there is no mystic charm in 1000 r.p.m. for tractor engines but that this speed merely indicates the state of the designer's ability to dissipate heat from bearing surfaces and to maintain films of lubricant under pressure and deflection of moving parts. Crankcases, crankshafts and camshafts that were extremely stiff in bending and in torsion were advocated.

In conclusion President Horning predicted that in the next 5 years the cost of tractors would be reduced and their utility augmented.

Design and Calculation of Coil Springs

E. W. Stewart, of W. D. Gibson Spring Co., very tersely summarized the points emphasized in his extremely valuable paper on the Calculation and Design of Coil Springs when he said that the design of springs involves a knowledge of what the spring is required to do, the application of a few simple mathematical laws to determine its dimensions, a consideration of how accurately it must be held and all of it tempered with ordinary common sense in keeping stresses within reason. Among the conclusions drawn by Mr. Stewart the following may be of especial interest: The calculation of coil springs can be simplified without detriment by ignoring all component forces to which the member is subjected with the exception of the torsion of the wire; the modulus of elasticity variously stated to range from 10,000,000 to 14,000,000 does not vary to this extent; the true modulus for drawn wire in all grades of carbon steel, whether tempered or hard drawn, for alloy-steels and for music wire was shown by actual tests to be 11,500,000 and did not vary by more than 3 per cent; a spring cannot be stiffened by a harder temper; the number of active coils depends upon the finish of the ends; in this factor lies much of the lack of uniformity in load characteristics of commercially produced springs; Begtrup's formula for the deflection of springs of square material is in error in that the constant k should not be unity but 0.843 for the square section, as has been shown by Saint-Venant; the same principles of design apply to both compression and extension springs; the application of formulas for design purposes involves a knowledge of stress limitations for the conditions under which the proposed spring is to operate; experiment shows that the important factor in spring operation is the range of stress through which operation takes place from the initial to the maximum load.

Mr. Stewart further stated the following conclusions: a manganese content much higher than that in the usual steels is best for springs; certain alloy-steels, notably chrome-vanadium and silico-manganese, can be operated at higher stresses than carbon steels, and at a given stress, if high, they will endure for a great number of repetitions of stress; in many cases no advantage accrues in using alloy-steels and in any case a high-grade, clean carbon-steel that is low in phosphorous is better than a dirty alloy-steel of any analysis; fatigue resistance depends largely upon surface condition; reasonable tolerances in springs depend upon their proportions.

ELECTRICITY ON THE FARM

THE slide-rule after all is not as unerring as the engineer sometimes thinks, especially when we have to apply it to the social needs of a community in which human understanding and human sympathies must be mingled with economics and mathematics to get a practical result. The manufacturer has not yet met by sufficient expenditure of energy or money the problem of the farmer. Without electrical machinery adapted to farm use, the farmer cannot extend the use of electricity to his profit. Unless he can extend to his profit, he will not use it; and unless he becomes a substantial consumer of power, it will be economically impossible for the power companies to supply the service. The manufacturing companies must endeavor to develop these agricultural applications. The farmer must be open-minded enough to use them. If these two things are done, the power companies, I am sure, can and will provide the necessary lines for the transmission of power.

When we substitute the power of falling water for coal that we do not produce, and the transportation of which clogs our railroads, we shall make a great step forward in all electrification, and not the least, the electrification of the farm.—Owen D. Young.

STANDARDIZATION ACTIVITIES

The work of the Divisions and Subdivisions of the S. A. E. Standards Committee and other standards activities are reviewed herein

20-HR. BATTERY RATING RECOMMENDED

5-Amp. Rating Which Is Widely Used Considered Technically Incorrect

At the meeting of the Storage-Battery Division held in Philadelphia on April 16, it was recommended that the present S.A.E. Standard for Storage Batteries be revised to specify a 20-hr., instead of a 5-hr., time rating. This change was voted only after a lively discussion as to the reasons for and against the 5-amp. rating, which is used extensively and the 5-hr. and 20-hr. ratings.

The 5-amp. rating has been recognized as standard by the Automotive Electric Association, having been adopted at a meeting held in March, 1924. The reasons for and against this rating and the time ratings were carefully reviewed in a comprehensive statement prepared by G. W. Vinal of the Bureau of Standards and issued with the approval of the Storage-Battery Division. This statement was printed in the February issue of THE JOURNAL on p. 149. Reprints were submitted to the passenger-car and motor-truck builders with the request that they indicate which of the several ratings they would prefer to see adopted by the Society.

The summary of the opinions received, copies of which were submitted at the Storage-Battery Division meeting, indicated a general preference for a time rating, only four companies indicating a preference for the 5-amp. rating. Of those in favor of the time rating, 21 preferred the 5-hr. and 15 the 20-hr. rating.

It was thought that the 20-hr. rating would be more acceptable to the industry than the 5-hr. rating, as the battery ampere-hour capacities based on the former, more closely approximate the capacities based on the 5-amp. rating. In the case of the 5-hr. rating the capacities are considerably less than those based on the 5-amp. rating. It was also decided at this meeting to express the 20-min. rating in amperes for 20-min., instead of in ampere-hours. The final voltage for the 20-hr. rating was set at 1.75.

As it was brought out by Dr. Vinal that the present battery ampere-hour capacities are exceedingly conservative, owing to the improvement in the art since the capacities were originally adopted, it was agreed to increase the capacities as indicated in the accompanying table.

PASSENGER-CAR STORAGE-BATTERY DATA

Battery No.	Minimum-Amp-Hr., 20-Hr. Rate	Minimum Amp. for 20 Min.
1	80	95
2	95	114
3	110	133
4	125	152
5	125	133
6	50	57
7	80	95

MOTOR-TRUCK STORAGE-BATTERY DATA

11	56	..
12	74	..
13	92	112
14	110	134
15	128	156

As the Division members were given to understand that the Automotive Electric Association would welcome a representative of the Division at the next meeting of the Association in order that the action taken by the Division might be properly laid before the Association, Dr. Vinal was appointed to represent the Storage-Battery Division at the next meeting of the Association.

Those present at the Storage-Battery Division meeting were W. E. Holland, of the Philadelphia Storage Battery Co., chairman; W. E. Gossling, of the Prest-O-Lite Co., Inc., vice-chairman; C. T. Klug, of the Willard Storage Battery Co.; George Kyle, of the United States Light & Heat Corporation; A. R. Lewellen, of the Chevrolet Motor Co.; A. D. T. Libby, of the Splitdorf Electrical Co.; E. L. Longaker, of the Electric Storage Battery Co.; I. M. Noble, of the Consolidated Battery Co.; J. L. Rupp, of the Westinghouse Union Battery Co.; B. L. Shinn, of the Associated Advertising Clubs; Dr. G. W. Vinal, of the Bureau of Standards; and C. E. Heywood of the S.A.E. Standards Department. A. D. T. Libby represented the Automotive Electric Association.

AERONAUTICAL SAFETY CODE COMPLETED

Sectional Committee Takes Final Action on April 23, at Washington Meeting

Final action in revising the American Aeronautical Safety Code was taken by the Sectional Committee at a meeting held at the Bureau of Standards, City of Washington, on April 23. Chairman H. M. Crane, who is past-president of the Society of Automotive Engineers, conducted the meeting, which was attended by 20 members, or alternates, as well as several members of different subcommittees.

The Sectional Committee, which was formed under the rules of procedure of the American Engineering Standards Committee, was organized at a meeting held in September, 1921. H. M. Crane, representing the Society, is chairman; J. H. Ames, representing the National Advisory Committee for Aeronautics, is vice-chairman; and M. G. Lloyd, representing the Bureau of Standards, is secretary. Every important body interested in aircraft is represented on the Committee and consequently the report may be considered as representing the consensus of opinion of the aircraft industry. An abstract of the code was printed in the January issue of THE JOURNAL on p. 25.

At the meeting on April 23, each part of the Code was gone over and suggestions for changes, that have been made since the different sections were printed, were considered. A large number of minor changes were made and the revised draft was then adopted by the Sectional Commitee. The Sectional Committee is, however, a continuing body and although the Code has been completed by the action at this meeting, the committee will continue to function in making future revisions from time to time, as they may appear to become necessary by progress in the art or, as a result of experience in applying the requirements of the Code in commercial aviation.

Most of the changes made in the Code at the April meeting were of minor importance, but the following are of special interest:

No definitions will be listed in the Introductory Part of the Code, as at first intended, but the glossary of the National Advisory Committee for Aeronautics will be referred to in this connection by title.

In Part 1, dealing with airplane design, the details for wood ribs as given in Rule 112 (*b*) were deleted.

In Rule 122, specifying the color code for the identi-

fication of pipe-lines, the committee decided upon orange to indicate fuel-pipes, yellow for lubricating-oil pipes, white for water-pipes, admiralty green for air-pipes and red for fire-extinguishing material-lines.

In Rule 130, the requirement for the ultimate strength of spruce was omitted and a requirement made that stresses in wooden members be based on the timber tests of the United States Forest Products Laboratory. This involves the assumption of a 15 per cent moisture content and a 3-sec. duration of stress.

In Rule 137 (*a*), specifying the assumed loads in the float supports of seaplanes, paragraph 4 was stricken out.

In Part 2 on Powerplants, Rule 211 dealing with tests of engines has a new paragraph added specifying that the engine shall be disassembled after the over-speed test and if any major parts are deemed to be unsafe for flying, the engine will be declared to have failed to pass the type test. The performance of the cooling system is specified in terms of the rise in temperature of the water, the rise being limited to 100 deg. fahr. above that of the surrounding air.

In Part 4, dealing with signaling equipment, the United States Regulations for Radio will be inserted.

In Part 7, it is specified that pilots of aircraft carrying passengers should have had adequate experience with the particular type of craft used.

The Code will be submitted to the sponsor bodies for approval. In the case of the Society, the Code will be submitted to the Aeronautic Division for Society action in accordance with the usual Standards Committee procedure.

ENGINE DIVISION RECOMMENDATIONS

Flywheel-Housing Size and Poppet-Valve Standards—Subdivision on Spark-Plugs

A recommendation for the adoption of a limited number of diameters and lengths for engine front-trunnions as S.A.E. Recommended Practice is to be circulated as a result of action taken at a meeting of the Engine Division of the Standards Committee in Chicago on April 14, at which it was also voted to recommend that data be obtained as to trunnion-bracket spreads and heights, especially from companies building engines of the larger sizes with front trunnions of the starting-crank bracket type and the gear-case type.

The meeting was attended by R. J. Broege, of the Buda Co.; A. A. Bull, of the Northway Motor & Mfg. Co.; F. S. Duesenberg, of the Duesenberg Automobile & Motor Co., Inc.; J. B. Fisher, of the Waukesha Motor Co.; A. F. Milbrath, of the Wisconsin Motor Mfg. Co.; L. F. Burger and O. B. Zimmerman, of the International Harvester Co.; A. W. Reader, of the General Motors Corporation; O. C. Rohde, of the Champion Spark Plug Co., and R. S. Burnett, manager of the S.A.E. Standards Department. It reviewed data from 54 engines made by 26 engine and car builders, nearly all of whom are large producers. Of these engines, 18 models have no trunnions.

The proposal is as follows:

PROPOSED S.A.E. RECOMMENDED PRACTICE FOR TRUNNIONS

Type	Trunnion Diameter, In.	Trunnion Length (Min.), In.
Starting Crank	2½	1¼
Bracket	3	1¼
Gear Cover	3¾	1½
	5	1½

Flywheels and Flywheel Housings

After discussion of a summary of data on flywheel counterbore which indicated that it was not practical to place closer limits than those specified in the present standard of 11.500 to 11.503 in. as printed in the S.A.E. Handbook on p. A1a, it was voted to recommend retaining the present limits but to add a note to the standard recommending that the limits for diameter of the clutch member be 11.499 to 11.497 in. This will allow clutch manufacturers to work to this limit on the mating clutch member, which gives a spread of from 0.001 to 0.005 in. maximum between the clutch member and the flywheel bore.

As engines requiring flywheel housings larger than the No. 1 size are principally for industrial use and are being made with housings even larger than No. 0, it was decided to circularize a proposal for a 31-in. housing to be designated S.A.E. No. 00 and to be to the following dimensions:

PROPOSED NO. 00 31-IN. FLYWHEEL HOUSING

Bore, 31.000 to 31.010 in.; bolt circle, 33½ in.; outside diameter, 34¾ in. with 12 holes 17/32 in. in diameter drilled for bolts equally spaced from the vertical center line of the housing.

It was pointed out that this size of housing, as now being made, has an outside flange to take through-bolts and that the No. 0 housing should have the same kind of flange. It was the unanimous opinion that adapters to enable the No. 0 housing to take smaller transmissions or clutches should be developed by the transmission manufacturers for their individual transmissions or to fit the desired transmission flange corresponding to a smaller standard flywheel-housing.

The subject of plain pilot bearings is to be discontinued, by unanimous vote, because (*a*) in practically all cases where plain-bushing bearings are used the related parts are made by the bearing manufacturers; (*b*) the tendency is to discontinue use of these bearings owing to difficulty of lubricating them, their rapid wear and consequent trouble; (*c*) they wear rapidly because of the side pull of the power take-off in industrial applications and (*d*) it was felt that nothing could be gained by standardization.

Proposed Piston-Pin and Bushing Practice

Because the piston-pin bushing usually is reamed for a larger pin when replacement is made and too many sizes of reamers are needed at present, it was decided to recommend for adoption as S.A.E. Recommended Practice the following specification for finished pins, to be made in even fractions of an inch with standard oversizes for replacements:

PISTON PINS AND BUSHINGS

All piston pins shall be finished to even 1/16-in. diameter with oversizes of 0.005 and 0.010 in. The purpose of this standard is to reduce pilot reamers for piston-pin bushings to the least number of sizes.

Proposed New Poppet Valve Standard

Mr. Fisher submitted a proposed new standard for poppet valves, the dimensions for which were worked out primarily for steel valves but which he said are also suitable for good cast-iron valves except for the contour under the head, where cast-iron valves should have more metal. Dimensions of this valve are shown on p. 495. It was voted to recommend adoption of the proposed valve in revision of the present standard on p. A4 of the S.A.E. Handbook.

Spark-Plug Recommendations

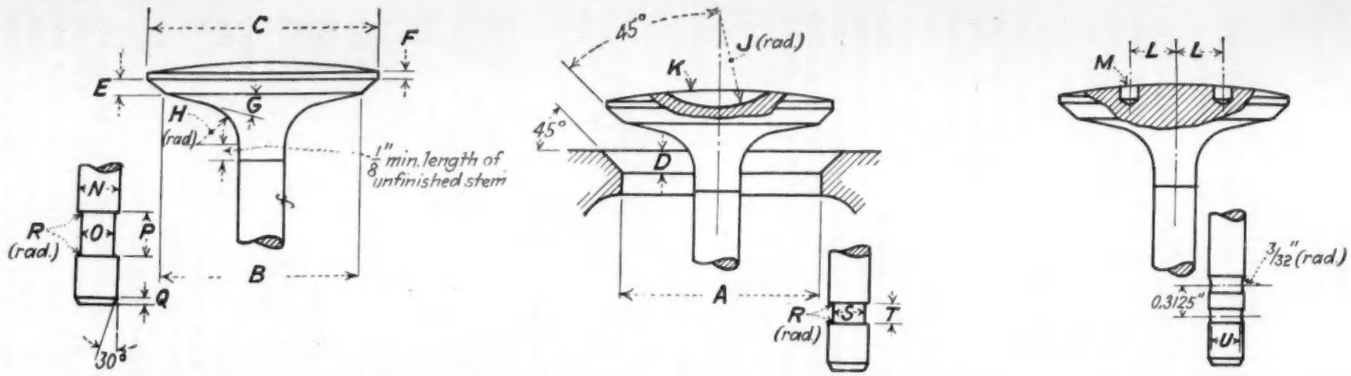
Action taken with regard to spark-plug standards was as follows:

Size of Hexagon.—Recommended that all spark-plugs have a standard hexagon of 15/16 or 1⅛ in.

Skirt Length.—Agreed that a longer plug should be included to take care of future practice and recommended that standard lengths of ⅝, 13/16 and 1 in. be adopted and that the length of thread for the ⅝ and 13/16-in. plugs be according to present standards, and recommended tentatively that the maximum thread length of the 1-in. plug be 23/32 in.

Terminal Threads.—Recommended that these be either No. 8-32 or 0.183-32.

Clearance.—Recommended tentatively that the minimum distance from the spark-plug seat to the nearest object over the plug be 2¾ in.



PROPOSED REVISION OF S.A.E. STANDARD FOR POPPET VALVES

Valve Heads and Seats													Valve-Stems and Grooves													
Nom. Size						G			K			M	N		O		P			R		S		T		U	
A	B	C	D	E	F	deg.	H	J	Width	Depth	L	Diameter by Depth	Max.	Min.	Max.	Min.	Max.	Min.	Q	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	31/32	1 5/32	1/16	3/32	1/32	7	1/4	3/4	1/16	3/32	1/4	1/8 x 1/8	0.3100	0.3090	0.250	0.245	0.328	0.322	1/32	0.012	0.008	0.235	0.230	0.144	0.138	0.250	0.245
1 1/8	1 3/32	1 9/32	1/16	3/32	1/32	7	1/4	3/4	1/16	3/32	1/4	1/8 x 1/8	0.3100	0.3090	0.250	0.245	0.328	0.322	1/32	0.012	0.008	0.235	0.230	0.144	0.138	0.250	0.245
1 1/4	1 7/32	1 13/32	1/16	3/32	1/32	7	1/4	1	1/16	3/32	1/4	1/8 x 1/8	0.3100	0.3090	0.250	0.245	0.328	0.322	1/32	0.012	0.008	0.235	0.230	0.144	0.138	0.250	0.245
1 3/8	1 11/32	1 17/32	1/16	3/32	1/32	7	1/4	1	1/16	3/32	3/8	1/8 x 1/8	0.3100	0.3090	0.250	0.245	0.328	0.322	1/32	0.012	0.008	0.235	0.230	0.144	0.138	0.250	0.245
1 1/2	1 15/32	1 3/4	3/32	9/64	3/64	7	3/8	1 1/4	1/16	3/32	3/8	1/8 x 1/8	0.3725	0.3715	0.309	0.303	0.391	0.385	1/32	0.012	0.008	0.253	0.247	0.144	0.138	0.309	0.303
1 5/8	1 19/32	1 7/8	3/32	9/64	3/64	7	3/8	1 1/4	1/16	3/32	3/8	1/8 x 1/8	0.3725	0.3715	0.309	0.303	0.391	0.385	1/32	0.012	0.008	0.253	0.247	0.144	0.138	0.309	0.303
1 3/4	1 23/32	2	3/32	9/64	3/64	7	3/8	1 1/4	3/32	3/32	3/8	1/8 x 1/8	0.3725	0.3715	0.309	0.303	0.391	0.385	1/32	0.012	0.008	0.253	0.247	0.144	0.138	0.309	0.303
1 7/8	1 27/32	2 1/8	3/32	9/64	3/64	7	3/8	1 1/4	3/32	3/32	3/8	1/8 x 1/8	0.3725	0.3715	0.309	0.303	0.391	0.385	1/32	0.012	0.008	0.253	0.247	0.144	0.138	0.309	0.303
2	1 31/32	2 5/16	1/8	11/64	1/16	12	7/16	1 1/4	3/32	3/32	3/8	1/8 x 1/8	0.4345	0.4335	0.312	0.306	0.516	0.510	1/32	0.015	0.010	0.312	0.306	0.175	0.169	0.372	0.366
2 1/8	2 3/32	2 7/16	1/8	11/64	1/16	12	7/16	1 1/2	3/32	7/64	1/2	5/32 x 5/32	0.4345	0.4335	0.312	0.306	0.516	0.510	1/32	0.015	0.010	0.312	0.306	0.175	0.169	0.372	0.366
2 1/4	2 7/32	2 9/16	1/8	11/64	1/16	12	7/16	1 1/2	3/32	7/64	1/2	5/32 x 5/32	0.4345	0.4335	0.312	0.306	0.516	0.510	1/32	0.015	0.010	0.312	0.306	0.175	0.169	0.372	0.366
2 3/8	2 11/32	2 11/16	1/8	11/64	1/16	12	7/16	1 1/2	3/32	7/64	1/2	5/32 x 5/32	0.4345	0.4335	0.312	0.306	0.516	0.510	1/32	0.015	0.010	0.312	0.306	0.175	0.169	0.372	0.366
2 1/2	2 15/32	2 29/32	5/32	7/32	1/16	12	9/16	1 1/2	3/32	1/8	1/2	5/32 x 5/32	0.5595	0.5575	0.437	0.430	0.578	0.572	1/16	0.020	0.015	0.405	0.398	0.206	0.200	0.495	0.489
2 5/8	2 19/32	3 1/32	5/32	7/32	1/16	12	9/16	1 1/2	3/32	1/8	5/8	3/16 x 3/16	0.5595	0.5575	0.437	0.430	0.578	0.572	1/16	0.020	0.015	0.405	0.398	0.206	0.200	0.495	0.489
2 3/4	2 23/32	3 5/32	5/32	7/32	5/64	12	9/16	1 1/2	3/32	5/32	5/8	3/16 x 3/16	0.5595	0.5575	0.437	0.430	0.578	0.572	1/16	0.020	0.015	0.405	0.398	0.206	0.200	0.495	0.489
2 7/8	2 27/32	3 9/32	5/32	7/32	5/64	12	9/16	1 1/2	3/32	5/32	5/8	3/16 x 3/16	0.5595	0.5575	0.437	0.430	0.578	0.572	1/16	0.020	0.015	0.405	0.398	0.206	0.200	0.495	0.489
3	2 31/32	3 13/32	5/32	7/32	5/64	12	9/16	1 1/2	3/32	5/32	5/8	3/16 x 3/16	0.5595	0.5575	0.437	0.430	0.578	0.572	1/16	0.020	0.015	0.405	0.398	0.206	0.200	0.495	0.489

Although the accompanying specification was formulated primarily for steel poppet valves, it is considered equally applicable for cast-iron valves except that it may be desirable to have slightly more metal in the latter under the heads.

Valve Lengths.—The over-all lengths of valves shall be measured from the large diameter of the valve seats to the tip of the stems and shall vary in increments of 1/8 in. on valves up to and including the 2-in. size and 1/4 in. from 2 1/4 to 3-in. sizes.

Grinding of Stems.—The ground length of stems shall be shown on valve drawings. The specified stem diameter limits shall be measured on and applied to only the ground portion of stems.

Concentricity.—The concentricity of the valve-seats with the ground stems shall be inspected by rolling the valves in a V-block, the length of which shall be the length of the ground stem, and relieved to not more than 1/2 in. from each end. The valves are to be held lengthwise by a ball bearing against the center of the tip of the stem. The indicator pin shall bear against the valve-seat at an angle of 90 deg.

When so inspected the total variation in indicator reading shall not exceed 0.002 in., that is, the valve-seats must be concentric with stems within 0.001 in.

Taper of Stems.—The maximum out-of-roundness or taper of valve stems shall not exceed the tolerance of the valve stem diameters.

Valve-Stem Tips.—Valve-stem tips shall be hardened to give a scleroscope reading of from 55 to 65 after finishing. It is recommended that the length of tips from the end of the stems to the stem-grooves be not less than the finished diameter of the stems so as to prevent undue breakage after hardening.

Spring Retainers.—The type of spring-retainer mechanism used shall be optional but the operations performed on valve-stems shall have the same machining limits as specified for the tips in the above specification.

Tolerance.—The tolerance on fractional dimensions shall be plus and minus 0.010 in.

Metric Plugs.—Voted to change the sub-caption of the present standard as printed on p. A11 of the S.A.E. HANDBOOK from Aeronautic Type to Metric Type, as the standard metric spark-plugs are used in automobiles, motorcycles and stationary engines, as well as in airplanes.

Firing Points.—Recommended that the maximum projection of the firing points below the body or skirt shall be 3/16 in. It was agreed, however, that definite lengths within this maximum should not be standardized.

As it is highly desirable to have the spark-plug standard used as nearly 100 per cent as possible, the following subdivision was appointed to review the present standards and foregoing recommendations and to communicate with certain engine and car builders in an effort to induce them to use only standard plugs in future production:

A. A. Bull, *Chairman*	Northway Motor Mfg. Co.
L. F. Burger	International Harvester Co.
F. S. Duesenberg	Duesenberg Automobile & Motor Co.
J. B. Fisher	Waukesha Motor Co.
A. F. Milbrath	Wisconsin Motor Mfg. Co.

CARBURETER THROTTLE LEVERS

To bring the threaded portion of carbureter throttle levers into accord with the S.A.E. Standard (American Standard) for Screw Threads, it was voted to recommend changing the 3/16-32 thread to No. 10-32, thereby eliminating the fractional size, the difference between the two threads being very slight.

A progress report on piston-rings was accepted.

ACTION ON PARTS AND FITTINGS

Proposed Changes in Fuel and Lubrication Tube Threads Recommended

To complete the present partial S.A.E. Standard for Fuel and Lubrication Tube Fittings, the Parts and Fittings Division of the Standards Committee, at a meeting in Detroit on April 20, voted to accept the report of the Subdivision having this subject in hand and to recommend its adoption by the Society. The report of the Subdivision contained the following recommendations for changes in the S.A.E. Standard for Compression-Type Tube Fittings as approved in part at the Standards Committee meeting in Detroit last January:

> That the thread for the ⅜-in. size be changed from 17/32-24 to 9/16-24; the thread for the 7/16-in. size be changed from 19/32-24 to ⅝-24; the minimum length of thread J for the 7/16-in. size be changed from 11/32 to 13/32, and the ½-in. size be adopted "as is."

The tube fittings in sizes of ⅛ to 5/16 in. were approved by the Society at the Annual Meeting in January with the exception of the limits for pitch diameters. The only changes in the complete report as submitted at that time are in the diameter of the threads, *F*, for the ⅜ and 7/16-in. sizes and changing dimension *J* for the 7/16-in. size from 11/32 to 13/32 and adding the limits for the pitch diameters for all sizes.

The report also recommended that the pitch diameters given in the table at the top of the next column be recommended to the Screw Threads Division for consideration, the recommendation being based on the Class D tolerances for special diameters and pitches; Table 45, p. 98 of the National Screw Threads Commission's Report of 1924.

Members of the Division were in attendance at the April 20 meeting as follows: W. C. Keys, of the Gabriel Snubber Sales & Service Co., chairman; H. S. Jandus, of the C. G. Spring & Bumper Co., vice-chairman; A. Boor, of the Willys-Overland Co.; W. J. Outcalt, of the General Motors Corporation; C. W. Spicer, of the Spicer Mfg. Corporation; F. G. Whittington, of the Stewart-Warner Speedometer Corporation; R. S. Burnett, manager S.A.E. Standards Department.

RECOMMENDED PITCH DIAMETERS

Tubing Diameter, In.	Thread Size, In.	Pitch, Diameter, In. Maximum	Minimum
1/8	5/16-24	0.2854	0.2821
3/16	3/8-24	0.3479	0.3446
1/4	7/16-24	0.4104	0.4071
5/16	1/2-24	0.4729	0.4695
3/8	9/16-24	0.5354	0.5318
7/16	5/8-24	0.5979	0.5941
1/2	11/16-20	0.6550	0.6509

SUBDIVISION ON BRAKE-LINING RIVETS APPOINTED

Because at present a needless variety of brake-lining rivets is in use and no standard method of designating their sizes exists, and believing that standards should be formulated for all rivets used by the automotive industry that are not under consideration by the Sectional Committee on Bolt, Nut and Rivet Proportions that is sponsored by the American Society of Mechanical Engineers and the Society under the procedure of the American Engineering Standards Committee, the Division voted to appoint a Subdivision to prepare a report on the subject and that upon completion and adoption of the Subdivision's report and the report of the Sectional Committee, all rivets that are included in the Sectional Committee's report that are used in the automotive industry be combined into one S.A.E. Standard for Rivets.

A Subcommittee consisting of A. Boor, chairman, W. J. Outcalt and Dr. F. C. Stanley, chief engineer, the Raybestos Co., was appointed to report on the following types of rivets:

(1) Small rivets for sheet metal
(2) Brake-Lining rivets
(3) Clutch facing rivets
(4) Tinners' rivets
(5) Rivets for fabrics, radiator lacings, etc.
(6) Any other type of small rivet not included above or not under consideration by the above-named Sectional Committee

CRANKCASE DRAIN-PLUGS

Acting on the suggestion of H. J. Saladin, of the Standard Oil Co. of Indiana, relative to standardization of the size of crankcase drain-plugs and the size of the external or internal squares of the plugs, the Division voted to request the Council to assign this subject to the Division and that a report on the subject be prepared by a Subdivision, of which H. S. Jandus was appointed chairman and W. C. Keys, the other member.

A Subdivision report of progress on gasoline-tank gages and filler tubes and caps for gasoline tanks and radiators was accepted and the Division approved the continuance of the investigation. Members agreed to obtain information from filling stations in their several localities as to the required size of gasoline filler tubes for various makes of vehicle to facilitate rapid and easy filling.

REPORT ON KEYS AND KEYWAYS

It was voted that a table of Woodruff keys giving the dimensions and tolerances as established by the Whitney Mfg. Co. be included in the S.A.E. Standard for Keys and Keyways. It is understood that the patents held by this company on this type of key have expired and that these keys are now being manufactured by other companies. It was also recommended that dimensions for the keyways in shafts and hubs be included for as many classes of key fits as investigation may indicate are required, and it was further voted that the report on keys and keyways should include square keys and keyways, taking into consideration the present S.A.E. Standards for Shafts and Shaft Fittings. The Subdivision on this subject was reorganized as follows: W. J. Outcalt, chairman; W. C. Spicer and K. L. Herrmann, of the Studebaker Corporation of America

Subjects Discontinued

After discussion, it was voted to discontinue the investigation on the method of gaging the serrations of shaft fittings, of shock-absorber mountings, and of revision of the sizes and toughness test for lock washers. Regarding the Rockwell test, it was believed that this is a purely metallurgical test and is inadequate for determining the toughness of lock washers without specifying also the material and the heat-treatment. The matter of lock-washer sizes is to be held in abeyance until completion of the report by the Sectional Committee on Bolt, Nut and Rivet Proportions, contact meantime being established with the Sectional Committee on Pins and Washers.

CLUTCH-BEARINGS STANDARD NEEDED

Present Over-All Dimensions for Release-Type Thrust Ball Bearings Vary

At a meeting of the Subdivision on Clutch Pilot and Release Bearings of the Ball and Roller Bearings Division held in New York City on April 8, it was brought out that practically no two sizes of clutch-release-type thrust ball bearing are alike in boundary dimensions.

It was agreed that an adequate standard based on dimensions of bearings now produced in greatest quantities, provided such bearings were not poorly designed to meet individual limitations, would be followed in future practice by automobile designers, and a large number of special bearings designed to meet the specifications of the individual car builders would thus be avoided in the future. Information is to be obtained from all manufacturers of this type of bearing in order that the Subdivision may draw up a recommendation which may be submitted at the Summer Meeting of the Standards Committee.

The standardization of clutch pilot bearings was also discussed at this meeting, it having been suggested that definite bearing numbers be assigned to the type of S.A.E. Standard used with a closure or pressed-steel oil-shield. In view of the facts that the bearing dimensions used are in entire agreement with the present S.A.E. 200, 300 and 400 series, that the practice of the different bearing manufacturers for the oil-shield is decidedly different and that developments may be expected in the near future, it was thought unwise to make any attempt to standardize such bearings.

Those present at the Subdivision meeting were J. A. Baninger, of the Gurney Division of the Marlin-Rockwell Corporation, chairman; C. D. Adams, of the Bearings Co. of America, representing D. F. Chambers; R. Gardner Cornforth, of the Nice Ball Bearings Co., representing Frank Beemer; T. C. Delaval-Crow, of the New Departure Mfg. Co.; D. E. Gamble, of the Borg & Beck Co.; and C. E. Heywood, of the S.A.E. Standards Department.

JOINT LUBRICANTS COMMITTEE NAMED

System of Identifying Suitability of Oils Based on Viscosity To Be Recommended

At a meeting of Committee D2 on Petroleum Products and Lubricants of the American Society for Testing Materials and representatives of the American Petroleum Institute held in Pittsburgh on April 3 and 4, a joint committee was appointed to draw up means for identifying the suitability of crankcase lubricating oils by a system of marking based on the viscosity at a given temperature. This action was taken as a result of the information submitted by H. C. Mougey, chairman of the Lubricants Division of the Society's Standards Committee, covering the revised S.A.E. Lubricants Specifications, given in full on p. 266 of the March issue of THE JOURNAL. It was understood at this meeting that the present S.A.E. Specifications are not in general use, the principal reason for this being that the specifications are too broad in their scope.

It was felt that the real purpose of the S.A.E. Specifications is to obtain a system of nomenclature generally recognized by the oil industry and used on oil containers so that the automotive manufacturers can recommend definite grades of oil for their equipment. The organization of the joint committee for the purpose of drawing up such a system of nomenclature met with the approval of those present at the meeting and the following committee was subsequently appointed:

R. P. Anderson, *Chairman*	American Petroleum Institute
I. K. Giles	Atlantic Refining Co.
K. G. Mackenzie	Texas Oil Co.
R. R. Mathews	Roxana Petroleum Corporation
J. B. Terry	Standard Oil Co. of California

BALLOON-TIRE PRESSURES RECOMMENDED

Tire & Rim Association Approves Table for Passenger-Car Straight-Side Tires

The proper inflation-pressures and loads for balloon tires has been the cause of a decided difference of opinion among tire manufacturers. The action taken at the April meeting of the Tire & Rim Association of America in approving a definite recommendation for the load and inflation-pressures of balloon tires is therefore of particular interest at this time. The recommendation, which is given hereinafter, does not represent the unanimous opinion of the members of the Tire & Rim Association, but is considered to be as nearly ideal as possible with the present state of the art.

LOAD AND INFLATION-PRESSURES FOR PASSENGER-CAR STRAIGHT-SIDE BALLOON TIRES

Inflation-Pressures, Lb. per Sq. In.	Tire Diameter, In.								
	4.40	4.75	4.95	5.25	5.77	6.00	6.20	6.75	7.30
22	500	580		700		850	900		1,150
24	550	635		760		925	980	1,100	1,260
26	600	690	725	820	880	1,000	1,060	1,200	1,370
28	650	745	780	880	950	1,075	1,140	1,300	1,480
30	700	*800*	835	940	1,020	1,150	1,220	1,400	1,590
32	*750*	855	890	*1,000*	1,090	1,225	*1,300*	1,500	*1,700*
34	800	910	945	1,060	1,160	*1,300*	1,380	1,600	1,810
36	850		*1,000*	1,120	1,230	1,375	1,460	*1,700*	1,920
38			1,055		*1,300*	1,450		1,800	
40			1,100		1,370			1,900	
42					1,440				

Figures in italics denote maximum desirable loads.

Weights are based on average passenger loads, which shall be taken as two for two and three-passenger roadsters and two, three and four-passenger coupes; three for five-passenger coupes, four and five-passenger phaetons and five-passenger sedans and four for seven-passenger phaetons and sedans.

The average weight of a passenger shall be considered to be 150 lb. When three passengers are taken, two shall be considered as being in the front seat, located half way between front and rear axles, and one on the rear seat, located directly over the rear axle. When four passengers are taken, two shall be considered in the front seat, located half way between the front and rear axles, and two in the rear seat, located directly over the rear axle.

In the case of front-wheel tires, it is recommended that from 2 to 4 lb. higher pressure be used than the table specifies, or, if desirable, the same pressure be used in front tires as the table specifies.

AUTOMOTIVE RESEARCH

The Society's activities as well as research matters of general interest are presented in this section

OIL DILUTION AND CONTAMINATION

Causes and Practical Remedies as Seen in the Light of Recent Experiments

The dilution and the contamination of the lubricating oil are at present the most prolific source of a variety of troubles encountered with internal-combustion engines. Consequently, this problem demands the immediate attention of the designers.

The direct reasons for the occurrence of dilution are now well known and may be classified as follows:

(1) Heavier fuel particles find their way from the combustion-chamber past the piston into the crankcase oil

(2) Water, part of the product of combustion, finds its way past the pistons into the crankcase

With regard to the dilution caused by heavier fuel particles, we know that the immediate consequence is a decided drop in the viscosity of the lubricating oil. Some interesting experiments[1] by Neil MacCoull show an approximate relation between the percentage of dilution and the consequent drop in viscosity.

Viscosity has justly been regarded as a very important characteristic of a lubricant. This is fundamentally correct because, ever since wheels were invented, it has been proved again and again that good lubrication is important; experience has shown that inferior lubricants are a source of constant worry, because (*a*) they have an immediate effect on the mechanical efficiency of everything that moves and (*b*) they have a profound effect on the length of life, and consequently, on the repairs required by all classes of machinery.

For this reason, a pressing need exists for a unit with which the quality of lubricating oil could easily and reliably be measured. For many years the viscosity has universally been accepted as the most satisfactory criterion, not only by engineers, but by laymen as well. Hence, operators of motor vehicles in the last few years were alarmed when, upon draining off the crankcase oil, they found its viscosity to be very much lower after some use than when the oil was new.

It was obvious that complaints were made first to the oil manufacturer because of the impression that the oil was breaking or cracking from wear, and later the responsibility was passed on to the designers who retorted with some wit to the effect that the kerosene instead of the oil spigot had been used at the last filling-station.

Lower End-Point of Fuel the Intrinsic Cause of Dilution

We are still passing through a transitory period during which motor fuel has changed from a highly volatile product to one of very low volatility. How much the end-point of the average fuel supplied to service-stations has changed in the last few years can be seen from the figures given at the top of the next column.

Year	End-Point, Deg. Fahr.
1910	320
1912	350
1914	390
1918	400
1922	427
1923	438

As the lowering of the end-point proceeded, attention had to be given quickly to carburetion, manifolding, air-heaters and hot-spots. These contrivances helped considerably to make engines run properly on fuels of an end-point around 450 deg. fahr. However, it did not occur to all responsible right from the start that engines would run fairly well with fuels even though the latter were not perfectly evaporated and instead were present in the manifold and the combustion-chamber in liquid form. It might have been anticipated that somehow this unvaporized fuel would have an effect on the lubricant which was splashed to the cylinder-walls and would also find its way into the crankcase.

Experiments which proved that fuel was running in streams in the inlet-manifold led the observers to the conclusion that at least in a cold engine all of this fuel would not vaporize even during combustion. This conclusion was later verified by some tests carried on at the Bureau of Standards.[2] In such experiments a quantity of fuel considerably in excess of that necessary for combustion is introduced into a tube, whereupon it becomes possible to obtain a series of explosions, solely by the addition of fresh air after each previous explosion.

In addition, it has been shown that the cylinder-wall temperature and similarly the temperature of the cooling medium have a very profound effect on dilution. For instance, in some tests reported by S. W. Sparrow and J. O. Eisinger,[3] this influence of the temperature of the cooling medium is shown to have an effect as is brought out in Fig. 1.

In some other experiments reported by H. C. Dickinson and J. A. C. Warner,[4] the following results are summarized from the very many tests that were carried on. It was found that dilution would increase some 43 per cent with fuels differing by only 55 deg. fahr. at the 90-per cent distillation point and having corresponding viscosities of 300 Saybolt sec. at 100 deg. fahr. for the new oil and less than 100 after some dilution at the end of a week's run.

Moreover, Mr. MacCoull in his paper[5] states that the temperature of the oil is very important. For example, he points out that raising the oil temperature 35 deg. fahr. reduces the total dilution about 50 per cent. The explanation of this fact is that with the higher oil-temperature we have, when other conditions are alike, much higher temperature throughout the engine, which causes the diluent to be boiled out. That this phenomenon is taking place is well established by other experiments, which have shown that, when starting a run, a new oil will be diluted quickly during the first few miles; the dilution will then increase rapidly and after running some 100 miles the oil will reach, with a constant temperature, a balance in dilution. If conditions are such that the engine runs very warm, the dilution even decreases.

It is understood, however, that the engine is not started cold in the meantime, because frequent cold-starting and even very rich mixtures greatly increase the dilution. These various disturbing conditions have made it very difficult to obtain consistent results. An oil may be diluted more in 150 miles of running than it sometimes is after a 500-

[1] See The Journal, July, 1924, p. 94.
[2] See The Journal, July, 1924, p. 73.
[3] See The Journal, February, 1925, p. 239.
[4] See The Journal, July, 1923, p. 92.
[5] See The Journal, July, 1924, p. 93.

mile run. For this reason, we shall treat the answer to the question of when an oil should be changed in the second part of this article, which deals with contamination.

Conflicting Opinions of Detriment Versus Value of Dilution

Some very interesting experiments which in some respects verify the theory that a small amount of dilution is desirable were conducted a little over a year ago by L. H. Pomeroy. The results of these experiments[6] reveal the interesting fact that an engine working under warm conditions with medium oil and water temperatures of about 150 deg. fahr., which corresponds to a viscosity of 110 Saybolt sec., will have 34 per cent less fuel consumption than an engine running under cold conditions with an average oil and water temperature of 100 deg. fahr., corresponding to a viscosity of 300 Saybolt sec. It is, of course, understood that the engine is working under conditions such as are encountered in ordinary city-driving.

Further, it is well known that after long periods of standing congealed oil makes starting in cold winter weather extremely difficult. In the wintertime, when viscous oils are slightly diluted with heavy fuels, starting and short runs are performed far more economically than they would be if a new and highly viscous oil served as a lubricant.

The preference for the use of somewhat diluted lubricants is further strengthened by some successful experiments that have been run wherein a lubricant composed of 50 per cent of oil and 50 per cent of kerosene was used. In fact, runs have been made wherein pure gasoline has been successfully used as a lubricant. Instances have been reported in which water has been used with some success. The well-known practice of lubricating two-stroke cycle engines by simply mixing 1 gal. of lubricating oil with from 10 to 20 gal. of gasoline is another good reason for this tolerance of and even confidence in highly diluted lubricants.

Categorically, we must agree, however, that a lubricant of doubtful quality may give satisfaction to some skilled operators in an experimental laboratory where the other conditions are ideal but, where varying conditions are encountered, it is necessary to have a reasonable factor of safety, even if it has to be paid for with a slight loss in mechanical efficiency. All the experimenters who are not alarmed by diluted oil should also know very well that no mechanism can run for any length of time without a lubricant and, most assuredly, kerosene or water is not the best of lubricants. Besides, we must have a good factor of safety even in lubrication; otherwise any change from the ideal would induce trouble.

The function of a lubricant is to provide a film of definite thickness between two rubbing surfaces. This film thickness is a function of the viscosity and of the pressure. In this film, dust particles may be absorbed and passed through the bearing surfaces without doing any harm, if the film is of adequate thickness. However, if, because of the presence of fuel, the viscosity is diminished and the film thickness is reduced, these abrasive particles will not pass in between the two bearing surfaces but will touch on both ends and cause wear.

As an analogy with regard to safety, let us take the case of a front axle. This could be made much lighter by the use of a steel having, in a heat-treated condition, a tensile-strength of about 200,000 lb. per sq. in., but, because of an occasional heavy shock, we have to be satisfied with a treatment that gives a tensile-strength of about 120,000 lb. per sq. in., with 55 per cent reduction of area, the great disadvantage of heavy unsprung weight notwithstanding.

In further support of this reasoning, let us quote F. H. Floyd, who recently stated that he ran an experiment on a well-known car over a period of 7 years, whereby the oil was changed every 100 miles and clarified. The oil was also built up to its original viscosity by recompounding to offset any dilution that had occurred. This car was run over 100,000 miles during that period without any wear being

[6] See The Journal, March, 1924, p. 307.

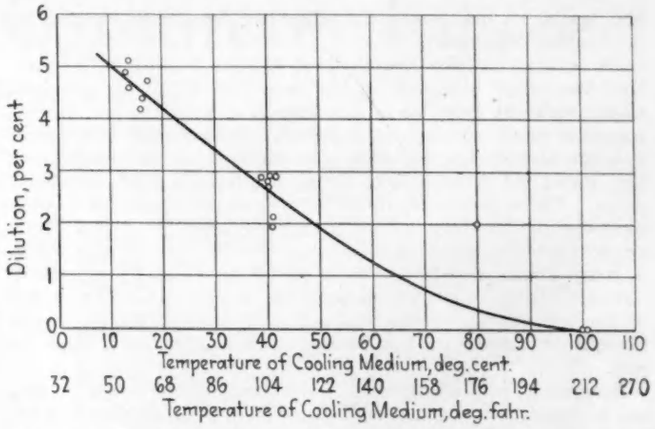


Fig. 1—Relation Between Temperature of Cooling Medium and Percentage of Dilution
Based Only Upon Tests with One Engine over a Rather Restricted Range of Conditions

perceptible on the main and the connecting-rod bearings, the pistons or the cylinder-walls. The car is still in operation, having covered altogether at the present time 150,000 miles. Mr. Floyd declares that, if oil is kept free from foreign substances, an internal-combustion engine can be run practically indefinitely without any appreciable wear.

To sum up it may be stated that the following points should be observed to avoid dilution:

(1) The engine should be kept warm by radiator shutters and thermostats
(2) Devices to assure easy starting should be given greater attention
(3) In cold weather the crankcase oil should be warmed-up by auxiliary devices
(4) Ribs on the crankcase should be avoided

Crankcase-Oil Contamination and Its Relation to Dilution

The direct reasons for the occurrence of contamination may be classified as follows:

(1) Part of the oil oxidizes because of contact with hot metallic surfaces
(2) Road dust finds its way into the crankcase through the breather and the inlet-manifold
(3) Metal particles that have been worn off are mixed with the oil
(4) Substances, such as lint from rags, abrasives, core sand and other foreign material, not removed before assembling, are washed off by the oil

One of the immediate results of the contamination of oil is the occurrence of a sludge at the bottom of the crankcase. This sludge has long been ascribed primarily to the presence of water and other foreign particles in the crankcase.

It is exceedingly difficult to prevent water from seeping into the crankcase. Some observers have noted water, after only 3 min. operation, in crankcases that were previously cleaned, dried and warmed. Water, being a product of combustion, is present in the combustion-chamber normally in the form of superheated steam. However, if this steam comes in contact with cold walls, it condenses, and for this reason engines that are frequently subjected to cold-starting are most noted for collecting water in the lubricating oil. However, the mechanical perfection of the engine has, of course, considerable bearing on that matter, for an out-of-round cylinder will never lend itself to sealing the combustion-chamber from the crankcase hermetically, no matter how perfect the pistons and the rings are made. Moreover, defective gaskets, cylinder and cylinder-head surfaces and possibly sleeves may allow a steady supply of water to percolate into the oil. A very interesting article pertaining to the relation of engine temperature to water deposition on

the walls of the combustion-chamber has been written by A. Ludlow Clayden.[7]

In several articles the General Motors Research Corporation has called attention to the fact that all motor gasoline, either straight gasoline or the blends of gasoline and benzol, contains small amounts of sulphur. On burning, this forms sulphur dioxide and trioxide, and these products, reacting in the water of combustion, form sulphurous and sulphuric acids. These products, in either vapor or liquid form, seep past the piston-rings where they collect on the metal parts or are scraped off and mix with the oil in the crankcase. A very small amount of acid added to water can greatly increase the tendency of metal parts to corrode. The oxides so formed are by themselves not only a most prolific cause for oil contamination but induce exceedingly rapid wear as well.

Because of the admixture of oxidized iron and road dust, the oil readily forms an emulsion. When this emulsified oil is circulated through the lubricating system, and is subjected to great centrifugal force, as for instance in the hole of the crankpin, the heavier particles are separated and form a more or less solid sludge. The quantity of this, of course, continually increases until the hole through the crankpin is completely filled and as a consequence the functioning of the lubricating system is impaired if the collection of sludge is not stopped.

Means for Preventing Contamination

A universal remedy for this condition is not so easily found. It is well known that the carbureter intake is the main avenue through which foreign matter enters the engine. For this reason many representatives of the automotive industry have taken particular interest in road and field dust and its relation to the wear of engines and other operating machinery. Very exhaustive experiments have been carried on with air-cleaners. That they have been very successful is evident from the records which have been published recently in THE JOURNAL.

Moreover, some very interesting devices have been developed whereby the oil, laden with dust, water and acid, that is behind the piston-rings is sucked away into a miniature refinery. Of course, not all of the injurious particles can so be removed, but considerable improvement is obtained. Some other purifying apparatus on the market consists of oil-filtering elements that are held in a container and are easily replaceable in case they become clogged.

The most primitive method is, of course, to protect the oil-sump and to prevent the pump from sucking in sludge and muck. The detrimental effect of the continual recirculation of a grinding compound with the oil can easily be observed from the appearance of bearings. It will frequently be found that the short crankshaft bearings are covered with more minute scratches giving a frosted glass appearance than are long bearings. The reason for this is that a much larger quantity of oil is circulated through a short bearing than through a long one. Consequently the differences in wear in general is wholly out of proportion to the specific pressures.

Some other experiments bearing on the subject under consideration were conducted by Ivan L. Anderson[8]. In these a study is made of the effects when a part or all of the air necessary for combustion is taken out of the crankcase to create a partial vacuum and consequent ventilation. Two obviously dangerous features go hand-in-hand with this method; (*a*) the air going into the crankcase is likely to deposit some road dust, which, of course, should be avoided, and (*b*) the oil consumption is likely to increase. However, neither of these obstacles can be classed as being absolutely insurmountable.

Another most insidious cause of contamination is found in the substances that are not removed before assembling the parts into a complete mechanism. In some instances, transmissions have been built with great care, but the number of rejections was excessive until special precaution was taken to wash all parts in soda water and to coat castings with an insoluble covering to eliminate loose core-sand. To mention that the difference between a new, quiet and efficient engine and a noisy and inefficient engine is simply a matter of wear is perhaps superfluous, in the light of some experiments previously mentioned; if the lubricant is kept clean, no necessity for an engine to wear exists.

In this connection, we may emphasize that oil should be changed frequently, not so much because of dilution but because of contamination. The instructions given by the manufacturer are a reliable guide in this respect. Of course, a large quantity of lubricating oil is wasted in so doing. Attempts have been made to reclaim such oil with the simple apparatus already commercially available. The Bureau of Standards has reported that reclaimed oil has been found to be as good as new oil.

While an attempt has been made to give an accurate survey of the status of the lubricating-oil problem, the feeling generally prevails that all the factors governing crankcase-oil contamination are not yet clearly understood. An effort to reach a better understanding was made by the Research Committee of the Society at the 1925 Annual Meeting in Detroit. At that time the fact that fundamental data are needed to show which factors are most worthy of investigation was emphasized. H. C. Mougey, control chemist of the General Motors Research Corporation, suggested that a large number of samples of crankcase-oil be obtained from various parts of the Country. The factors to be investigated in the analysis of the samples include (*a*) the amount of dirt in the oil, (*b*) the rate at which dirt accumulates in a lubricating system, (*c*) the amount of trouble caused by dilution, (*d*) the importance of controlling the cylinder-wall temperature and (*e*) the effect of crankcase-oil temperature.

In conformity with the conclusions reached at that meeting, the Society's Research Department has made arrangements, through the headquarters of companies producing passenger cars and trucks, for samples of used crankcase-oil to be obtained from the cars in Birmingham, Detroit, Minneapolis, New Orleans, San Francisco, Tulsa and the City of Washington. These cities were selected as representing the desired variation in climatic conditions and other factors, such as the dust carried in the air that the engines must breathe. Some 700 samples so collected will be sent to the Bureau of Standards and will be analyzed there following the best-known procedure.

Results of the analyses will be furnished to the cooperating manufacturers and a summary of the investigation will be compiled later for the information of all concerned. Positive knowledge of the materials that impair the lubricating quality of oils and cause most wear will enable the builders of cars and trucks to devise means for increasing the life of motor vehicles. It is likely that independent researches are being conducted simultaneously by various companies and this opportunity is taken to extend an invitation to all those now working on this subject to communicate with the Research Department, so that all may join in the common effort to arrive at a solution whereby the industry and the car-owners should profit in general.

[7] See THE JOURNAL, July, 1924, p. 47.
[8] See THE JOURNAL, July, 1924, p. 43.

Best Location for Carbureter Intake

By A. H. HOFFMAN[1]

LOS ANGELES GROUP PAPER *Illustrated with* PHOTOGRAPHS

ABSTRACT

TESTS to determine the location under the hood of a motor vehicle where the air-intake of the carbureter will be exposed to the least dust were made by the agricultural engineering division of the University of California at Davis, Cal., and the results are given in the hope that they will serve a useful purpose. Of three types of dust-screen devised to catch the dust at different locations so that it could be photographed, yet which would present little hindrance to passage of the air from point to point under the hood, the most effective was one of coarse hospital gauze stretched over frames set in transverse vertical positions on either side of and above the engine.

The tests were made on two phaetons and a speed truck, run for less than 3 miles and following another car on a dusty road. Photographs show the screens in position in the vehicles and removed to show the distribution of dust as collected under various operating conditions, as with the radiator fan idle and with it revolving with the fan-belt normally tight.

The conclusion reached as a result of the tests is that, in normal cases, the best carbureter-intake position would seem to be (*a*) on the side of the engine on which the fan-blades have a descending motion, (*b*) about midway between the radiator and the dash, (*c*) about midway between the side of the hood and the center line of the engine, and (*d*) about one-third of the distance down from the top of the hood toward the top of the cylinder-head.

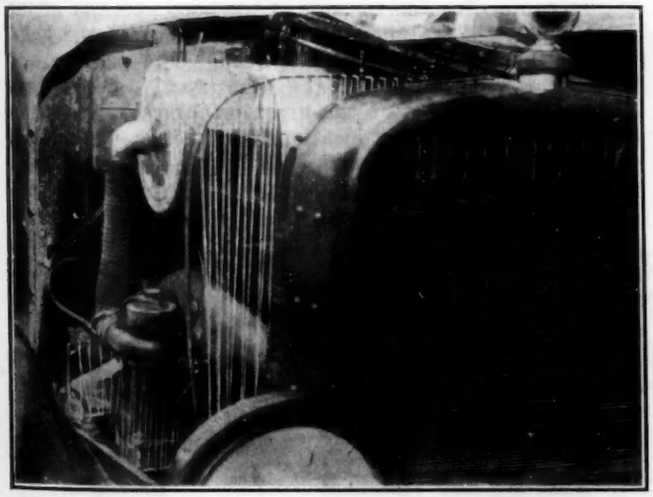


FIG. 1—INDICATOR SCREENS OF WHITE COTTON TWINE IN POSITION
These Gave a Fair Indication of Relative Quantities of Dust at Different Locations under the Hood but Were Not Satisfactory for Making Photographs of the Results. The Picture Was Taken Before the Test Began

WHERE it would encounter the least dust is, evidently, the best place under the hood to locate the air inlet of a carbureter. Several tests just made at Davis, Cal., by the agricultural engineering division of the University of California had as their object

[1] Agricultural engineering division, University of California, Davis, Cal.

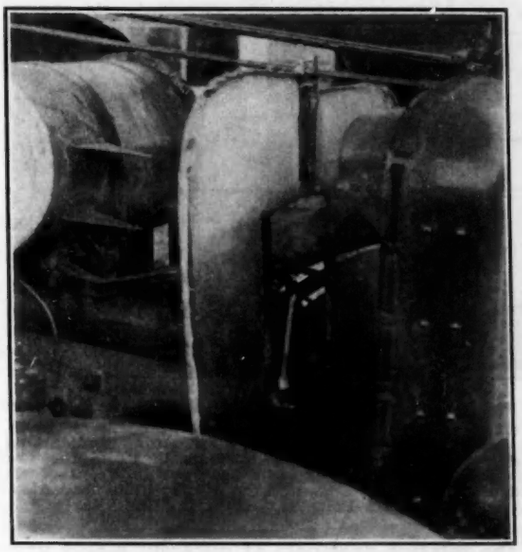


FIG. 2—SCREENS OF COARSE-MESH HOSPITAL GAUZE
These Were Used in Transverse Vertical Planes Only, in the Second Attempt To Secure Records

to determine the relative dustiness of various locations under the hoods of three machines. The first efforts were not aimed at an exact quantitative determination and may be supplemented by more exact work. However, since the determination of the best available place is probably all that usually would be required in practice, it is hoped that the methods here indicated may serve a useful purpose.

A Ford phaeton, a Studebaker Light-Six phaeton and an I. H. C. 1-ton speed truck were fitted successively with devices for indicating to the eye or to the photographic

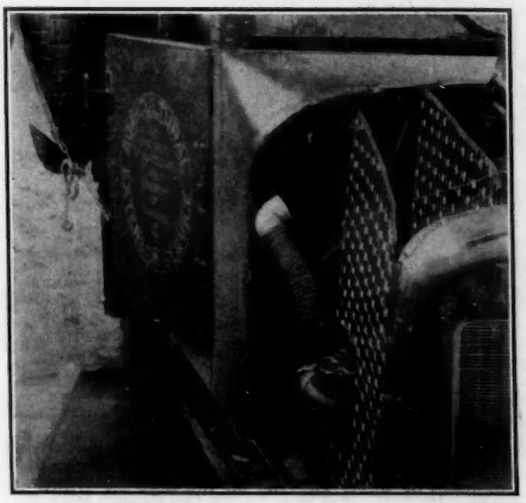


FIG. 3—WIRE-MESH AND WHITE-FELT SCREENS IN VERTICAL LONGITUDINAL POSITION

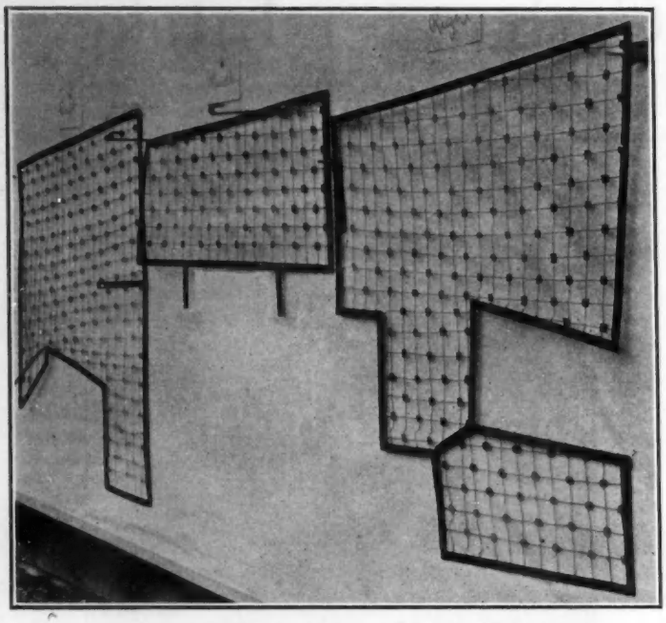


FIG. 4—SCREENS WITH SQUARE WHITE-FELT INSERTS
The Felt Squares Were Inserted at Alternate Intersections of the Wires and Moistened With Oil. Satisfactory Indications Were Secured with These Screens. This View Is From the Left Side, Rear Quarter. Concentration of Dust Just in Front of the Dash Is Evident. The Rear Edges of the Upper Felts Are Also Dusty. The Fan-Belt Was Tight in This Test

plate the relative dustiness at different places under the hood. The machines were then run for less than 3 miles, following another car on a dusty road. The dust-holding devices were designed so as to offer little hindrance to the passage of the air from point to point under the hood, especially when the object was to determine as between front and back positions. Hence the metal frames for supporting the dust-catching materials and these dust catchers themselves were placed with their longer dimensions approximately parallel to the air stream as the illustrations indicate.

In the first attempt, ordinary white cotton wrapping twine, moistened with Household Lubricant diluted with four volumes of high-test gasoline, was wound around the frames, as in Fig. 1. The spacing for adjacent turns of the twine was about ¾ in. While this gave positive indications, it was not sufficiently definite to give good photographs.

In the second attempt, coarse-mesh white hospital gauze, similarly moistened with oil, was employed, as in Fig. 2. It was used only for determinations in transverse vertical planes, since its presence in longitudinal planes might conceivably have changed the air-flow under the hood from its normal direction.

In the third attempt, screens of No. 22 iron wire, with meshes 1¼ in. square, were woven on frames of ⅛ x ¾-in. iron built to fit the space where the determinations were to be made. At alternate intersection points of the wires 1/3-in. squares of white felt, 1/16-in. thick and oiled as before indicated, were pushed in and held by friction between the wires, as shown in Figs. 3 and 4. These gave satisfactory indications.

It appears from the photographs reproduced in Fig. 5 that when the fan-belt is loose the dust distribution is more uniform on both sides of the engine and is considerably less above the midplane than below, as revealed by the darker portions of the screens shown in the photograph at the left. When fan-belt is normally tight, the fan tends to throw the dust up from the rising blades, thus increasing the dustiness in the upper spaces on that side of the engine, as indicated by the screens in the central picture.

In the case of normal fan-belts and no shroud around the fan, it was found that there was less difference in dustiness between the two sides of the engine but that an upper current of air and dust passed back to the fan just under the top of the hood.

For the normal case, it would seem that the best inlet-position would be (*a*) on the side of the engine on which the fan-blade tips descend, (*b*) about midway between the radiator and the dash, (*c*) about midway between the engine center-line and the side of the hood and (*d*) about one-third of the distance down from the top of the hood toward the top of the cylinder-head. The presence of accessories, shrouds and the like would necessitate making a special test on the given machine to determine exactly what is the best location for the inlet under that particular set of conditions.

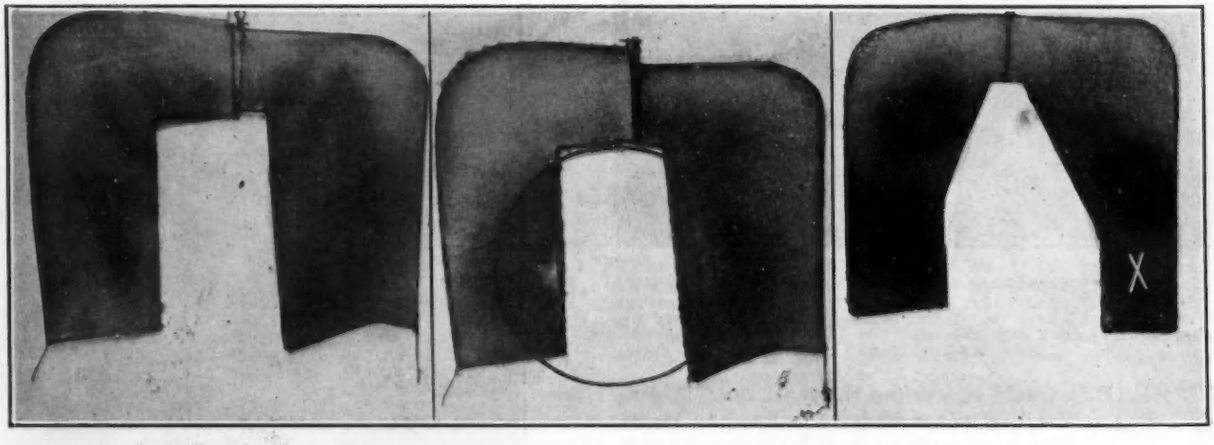


FIG. 5—RESULTS OF TESTS OBTAINED WITH TRANSVERSE VERTICAL SCREENS OF HOSPITAL GAUZE
Left View Shows Uniformity of Dust Distribution on Both Sides of Engine with Fan-Belt Off. Center View Shows Greater Dustiness in Upper Regions on the Side on Which the Fan Blades Were Ascending When the Fan-Belt Was Normally Tight. In Both of These Views the Screen Was Placed 9 In. Back of the Radiator on an I. H. C. Speed Truck. Right View Shows Little Difference in Dustiness of the Two Sides of the Engine with the Fan-Belt Normal but Notable Predominence of Dust in the Lower Regions. This Screen Was Located 8 In. Back of the Radiator on a Studebaker Light-Six Phaeton. The Position of the Carbureter Air-Intake Is Indicated by X

The Automotive Storage Battery, Its Operation and Care

By T. R. Cook[1]

METROPOLITAN SECTION PAPER

ABSTRACT

FOUR factors limit the length of life of a storage battery; (*a*) its design, (*b*) its quality, (*c*) the degree of excellence of its maintenance and (*d*) the relation between the current supplied to it by the generator and the current demanded from it by service. Three other factors, weight, size and cost, have influenced designers to produce a battery considerably smaller than formerly was thought desirable and to make each of the three as low as is consistent with the attainment of from 1½ to 3 years of service. Naturally, this smaller battery is operated at rates considerably higher than those used for large batteries, and it requires closer attention in regard to filling with water, cleansing and regulation of the current input from the generator.

Although a constant-potential generator permits the attainment of the maximum length of storage-battery life, its high cost and its demand for expert maintenance attention have caused engineers to substitute for it a third-brush machine, this being essentially a constant-current piece of apparatus that has a tapering rate of charge as the speed of the car increases.

The subjects of current input and battery troubles are discussed briefly, followed by a statement of four specific suggestions relating to proper storage-battery maintenance, inspection and advice to car-owners. In addition, five general cautions are given.

A HEALTHY storage-battery that has its generator input properly proportioned to the service required will operate in an entirely satisfactory manner and have only two requirements. One of these is the necessary filling with distilled water to keep the electrolyte above the plates and separators and the other, proper maintenance such as the cleaning of the battery to remove the dirt and corrosion that accumulate on top, and the occasional removal and covering with vaseline of the terminals to assure contact and preserve the new contact for the greatest length of time.

The greater portion of battery trouble experienced by the automobile owner occurs when his particular battery has finished its useful life and requires renewal or the attention of a competent battery repairman. This length of life depends upon (*a*) the design of the battery, (*b*) the quality of the battery, (*c*) the care given it by the owner or his agent and (*d*) the relation between the current put into the battery by the generator and that taken out in service.

A battery for an automobile can be built of sufficient size and having a sufficient number of heavy plates and wide enough separation between the plates so that, if it is given proper care as to filling with water and cleaning, it will perform for 4 or 5 years in an entirely satisfactory manner. However, a commercial compromise has been thought by automotive engineers to be advisable, and this has resulted in the furnishing of a considerably smaller battery. This compromise was effected by modifying three factors, weight, size and cost. Automotive engineers have deemed it desirable to hold the weight, dimensions and cost as low as is consistent with obtaining from 1½ to 3 years of service. Naturally, since this smaller battery is operated at considerably higher rates, it requires closer attention in regard to filling and cleaning and regulation of the generator input.

The automotive engineer is careful, as a rule, in the selection of a battery, and decides on a quality article which will meet the requirements of storage-battery life under ordinary service. At the end of the life of the battery originally installed on the car, the owner may install a battery of indifferent or poor quality and thereby aggravate battery troubles severely.

CHARGING EQUIPMENT

With respect to the charging apparatus on the automobile, a good constant-potential machine will permit the attainment of maximum battery-life. However, constant-potential machines have been high in cost and have required such expert attention to maintain them at their proper operating-efficiency that automotive engineers have found it desirable to compromise again. They have substituted the third-brush machine; which is essentially a consant-current piece of apparatus that has a tapering rate of charge as the speed of the car increases.

The current input to the battery is calculated by the engineer to meet the requirements of the ordinary car driver, but there are extremes in the operation given a car by drivers. They range from the service required by the owner who uses his car only for touring that is done principally in the day time, requiring very little use of the current and therefore very little input from the generator, to the demands of the doctor who uses his car day and night on short slow runs that require frequent use of the starter which, in the aggregate, calls for a considerably larger input of current. To make matters worse and going hand in hand with the extreme requirements of the service, in some machines on the market the current input to the battery from the generator varies remarkably with the different cars. For instance, in my experience, a certain type of car presumably designed to deliver a normal amount of current of 7½ amp. to the battery was found to have a current range of from 2 to 18 amp. If a doctor were unfortunate enough to get the car with the 2-amp. current input, he would undoubtedly have his battery taken off the car and charged a number of times a month. If the tourist had the car with the 18-amp. current input, he undoubtedly would burn up the best of batteries in 2 or 3 months of service.

It is very difficult to estimate the current requirements of a storage-battery for any given individual use, but the current input from the generator can be adjusted as the result of the operation of the car indicates the necessity; that is, if a particular car is requiring occasional recharging of the battery, the chances are that the trouble can be eliminated by installing a third brush to give an increase of current input.

If the ignition or the carbureter are at fault, requiring

[1] M.S.A.E.—Vice-president and general manager, Westinghouse Union Battery Co., Swissvale, Pa.

excessive use of the battery in turning over the engine at each start of the car, this would result in depleting the current in the battery; or, there may be a partial ground, resulting in a current leakage from the battery. The question of leakage of current can be investigated by first seeing to it that all normal current outlets are open, such as lamps, cigar lighters and other apparatus; then, after disconnecting one terminal on the battery, ascertain whether a spark can be obtained by bringing the loose end of the terminal into contact with the battery terminal posts. If a spark is obtained it is absolute evidence of a leakage of current; such leakage must be eliminated to put the apparatus in good working condition. The question of excessive use of the starting apparatus can be investigated by asking questions of the owner. The other extreme, too much input by the generator, is evidenced by an excessive requirement of water, and the battery will always show a high specific gravity. This can be cured by decreasing the input from the generator to the battery by the proper setting of the third brush.

Summary

It is suggested that, with respect to batteries, the following points be given consideration in regard to maintenance, inspection and advice to car-owners:

(1) Keep the electrolyte in the battery from ⅛ to ¼ in. above the tops of the separators, filling with distilled water when occasion demands

(2) Keep the top of the battery dry and clean

(3) Keep the contacts between the terminals and the posts in good condition by keeping them tight and protecting them from corrosion with vaseline

(4) See that the generator is producing the proper amount of current to care for the needs of the individual user

General Cautions

(1) Care should be exercised to see that the car wiring does not develop partial short-circuits due to worn insulation or other causes

(2) Keep the ignition and the carbureter in proper adjustment to assure immediate starting of the engine

(3) See to it that the starter switch-contacts are maintained in good condition. Corroded or dirty contacts will introduce considerable resistance to the starting-motor circuit and result in slow speed of the starting motor, late firing of the engine and a considerably greater output from the battery than would be necessary if the starting switch were in good condition

(4) In regard to the purchase of a new battery to replace an old one, advise the car-owner to buy one of the best quality and of the largest capacity that he can install on his car

(5) If, after having had proper attention, a battery refuses to perform satisfactorily, it probably is in need of the services of a competent battery repairman

THE DISCUSSION

Chairman C. B. Veal:—We are very much indebted to Mr. Cook for presenting a paper that covers so thoroughly all the points in connection with the use and operation of a part of the car which, I think, is as little known to the average owner as any other part. He may know as little about the carbureter and some of the other features, but he tinkers with them so much that he thinks he has learned something about them; whether he ruins the car or not is another question. But he is afraid to do anything with his battery, lest he will be unable to operate his car at all.

Bruce Ford[2]:—Mr. Cook mentioned a doctor's car, the battery of which might receive only a 2-amp. charge from the generator. In such a case, the doctor unquestionably would have trouble; but, if the generator were set for 18 amp., I doubt very much if even the tourist would have any trouble, provided he gave the battery sufficient water whenever it needed it. The battery would require watering very much oftener at 18 amp. than it would at 2 amp.

Many batteries are supposed to have been burned up from overcharging them, in reality, the trouble with the battery was due to something entirely different or something contributory. I have never seen an automobile battery that has been hurt solely by being overcharged. We made some experiments with constant charging, never allowing the battery to rest and recover from the continuous charging and never giving it any discharge which would give relief from that constant strain. As the result of the constant charge, we estimated that it represented about 50,000 miles of continuous driving at about 25 m.p.h. In every case of unusually long life, we have always found that, according to some standards, the battery always has been overcharged. Whenever a battery is undercharged, it is bound to give trouble because, no matter how large the battery is, it will never get into a complete state of charge unless the amount of discharge from the battery is less than the amount of charge. Regardless of the capacity of the battery, or its size, it only represents a reservoir, and, with less going in than is being taken out sooner or later any battery will get flat and require a bench charge or something more serious, depending on how far this condition has been allowed to progress.

It must be very rare to have the generator set so that it always gives just the right amount of charge to take care of the amount that has been taken out of the battery. I suppose there are no two cars in the hands of the same user, or in the hands of any two users, the batteries of which receive the same amount of discharge with any degree of regularity. Only one salvation exists; the generator should be set high enough to take care of the maximum condition, otherwise, if the generator is set lower than that and if the total discharge is greater than the total charge, the battery will get flat. I believe that it can generally be stated that in ordinary service overcharging will not hurt the battery of a starting and lighting system, provided it is given enough water.

This matter of watering storage-batteries probably has not received adequate attention in regard to the instructions given to the user. In ordinary operation the user is prone to think that he will fill his battery at some regular period, irrespective of how he is using it. If his generator is set to overcharge the battery, and I maintain it should be, the more miles he drives his car and the more charge he puts into his battery, the more water it will decompose and the oftener it needs refilling; so, why can we not establish some rule of filling the battery every certain number of miles, regardless of how the car is driven? The tourist, then, would run off that amount of mileage in a shorter time and he would need to fill the battery much more frequently.

With respect to the general impression that the starting current exhausts the capacity of the battery; it does, of course, in some degree. Any discharge tends to exhaust the battery, but I think we are prone to lay too

[2] M.S.A.E.—Third vice-president, Electric Storage Battery Co., Philadelphia.

much emphasis on the amount of exhaustion due to a start. An ordinary size battery, such as is used in an automobile, has say a 100-amp-hr. capacity. An ordinary start takes a fraction of an ampere-hour, or less than 1 per cent of the capacity of the battery. With that in mind, you will get a better conception of the comparative drain on the capacity of a battery caused by continual starts. If you are waiting for something to happen and have nothing to do but wait for it to happen, time passes very slowly. If you are waiting for your engine to start, when you put your foot on the starting pedal, 10 sec. pass very, very slowly. Take out your watch and time it. It will impress you as being an unusually long time for starting, and it is; but it is only 1/360 of an hour, or less than 0.5 amp-hr. at 150 amp.

W. E. HOLLAND[3]:—It is very hard to get the average user to understand the necessity for looking after his battery. Mr. Ford suggests persuading the user to add water to the battery after running a certain number of car-miles; that is fine, but if you can get him to look into the battery at all, you will do well. Many people never pay any attention whatever to the battery; they do not know it is in the car and, if it were not for the garage men, the battery would certainly suffer.

The car builders often make things very hard for the battery, and they have not improved much even after all these years of using batteries. The worst trouble is due to the use of undersized batteries. In these days of keen competition they are all trying to save the pennies wherever they can, but it is certainly unfair to the user and unwise to install a battery that is really too small for the work, when a battery slightly larger and costing slightly more would perhaps last twice as long and give better service. The builders are also at fault in not protecting the battery from water and dirt. In some cars the battery is absolutely open, and mud and water are thrown upon it. I have even seen a battery in which the sealing was broken open so badly at the top, due to lack of proper hold-downs, that, the cracks where the sealing had broken away were full of sand and gravel thrown up from the road. The matter of providing proper hold-downs that will not loosen is important. The battery should be well supported, so that it cannot shake around.

Batteries are now installed where they are more accessible than formerly, as a rule, but now and then we find a very bad offender in that respect. For instance, one car that is very popular and has a large sale came out recently with a small battery under the floor, and the floor was screwed down. The owner was not likely to know that a battery was located there or give it any attention whatever, because to attend to it, he had to take the screws out of the floor-boards and lift them up.

Battery troubles, according to what we have already heard, are due chiefly to two directly opposite things. One is overcharging and the other is undercharging. I cannot agree with Mr. Ford that not much trouble from overcharging is experienced. I think considerable trouble due to overcharging is encountered, even when water is added to keep up the solution level. Contrary to the usual belief, buckling of the plates is more often caused by overcharging and the resultant overheating than by over-discharging, and buckled plates will often cut right through the separators and short-circuit a battery before the active material of the plates shows any signs of wear.

Unquestionably undercharging is the cause of much trouble, particularly in winter. Cars are not used as much in winter as in summer, and in many cases the car is not driven enough in winter to replace the current drawn from the battery. When the battery fails to turn the engine over, the owner blames the battery or says it is affected by the cold, when really the trouble is that it has not been getting enough charge. The source of the trouble is not the battery but the generator, which is too small for winter requirements. Batteries that are run down repeatedly, due to insufficient charging, will have a comparatively short life.

Regarding special electrolytes, many of which are sold under various names, I have as yet found none that has any merit whatever, and we have investigated a great many. They are more likely to do the battery harm rather than good, if they do anything at all. Usually they consist of ordinary sulphuric acid, perhaps colored or with a little sodium sulphate or other material added to make the solution look different. The battery will often show increased "pep" temporarily when the electrolyte is changed, even if you simply pour out the old acid and put in new. This occurs particularly if the battery is partly discharged when the change is made. The acid is then weak because a large proportion of it has combined with the plates. Being filled with stronger acid than is poured out, the battery may show a temporary improvement in capacity but the net result is to do considerable harm to the plates and shorten the life of the battery.

Starting batteries have been greatly improved and the starting battery of today is very much better and more reliable than that of a few years ago. Improvement of the plates and separators has gone on quietly but steadily and I believe that most of the reliable makes are constantly getting better. One trouble used to be the great variation in manufacture. A number of factors were not under control and a great variation was found between different batteries turned out by the same factory. I know that a great improvement has been made in this respect. Still, there are many batteries on the market which are made and sold simply on price, with no knowledge or experience back of them. Of such the wise buyer will be wary.

E. W. ALLEN[4]:—Thomas A. Edison has not as yet developed a nickel-iron storage-battery that is suited, by its characteristics, for automotive starting service. The main reasons are its higher internal resistance and the lower voltage characteristic at the high rates of discharge that a starting motor requires. However, the Edison company has been developing ignition and lighting batteries.

At present, many truck companies do not equip their motor trucks with starting systems because of the added mechanical difficulties involved, and equip them with a lighting and ignition system only. The Edison company has about 10,000 batteries that are being used by these various truck companies for ignition and lighting; this also includes taxicabs. The generating system, as found on these trucks, is not adequate to charge an Edison battery.

The main types that we use are the B-2, of 37.5-amp-hr. capacity and normal discharge rate of 7.5 amp.; the B-4, of 75.0-amp-hr. capacity and normal discharge rate of 15.0 amp. and the B-6, having a 112.5-amp-hr. capacity and a normal discharge rate of 22.5 amp. These figures are based on a discharge period of 5 hr. We

[3] M.S.A.E.—Research engineer, Philadelphia Storage Battery Co., Philadelphia.

[4] Sales engineer, Edison Storage Battery Co., Orange, N. J.

require that the battery be charged at the normal rate to obtain the best results and, to complete the charge, a voltage of approximately 1.8 volts per cell is required. The necessary charging voltage for 4 cells is four times 1.8 or more than 7.0 volts. The lights then will be very bright while the generator is on and will be dim from the four cells when the generator is disconnected, because each gives 1.2 volts at its normal discharge rate. Five cells have been used, but this introduces a difficulty in charging. The generator then must furnish the battery with so much current that it is liable to burn out the lights but, on discharge when the generator is disconnected, one will get very fair lights.

Consequently, at present, the truck and taxicab people who are using our batteries have discarded altogether the generating systems supplied on their trucks and taxicabs and are giving the batteries a straight bench charge. Of course, this adds to the maintenance cost and the charging of the batteries cannot be disregarded as it can where a generator system is provided. In 10,000 cases the companies have seemed willing and anxious to use the battery, even to the extent of discarding the generating system and using a bench charge.

It appears that the solution of the problem of ignition and lighting is to use a generator perhaps of the third-brush variety, which will furnish the battery with approximately 1.7 volts per cell, and employ five cells. Also, that an extra pair of contact points be put on the reverse current relay so that, when the generator is connected into the circuit, a small ballast series resistance will be thrown into the lamp circuit to bring the lights down to the proper amount of illumination and brilliancy. Then, when the generator is disconnected from the battery, this extra pair of contacts will automatically take that resistance out of the circuit and the battery will then furnish the lights with current to give the same brilliancy.

H. M. MARTIN[5]:—The wonder in my mind is that a storage-battery can exist under the conditions prevailing when it is being charged. A third-brush generator is a machine that does not recognize the condition of the battery, and it furnishes current irrespective of the battery's needs. It is therefore astonishing that a battery is able to survive under such treatment, and shows that the storage-battery is a rugged piece of apparatus. There have been and are various modifications of third-brush machines that adapt them better for battery charging. When the lights are in operation, one device cuts-out of circuit a resistance coil in the field of the generator. Then, when the lights are not in use, the resistance is switched in so that the amount of current going to the battery remains practically constant whether the lights are on or not. Of course, the ideal system of battery charging is that of constant voltage. At present, voltage regulators are made that are much more reliable than those of past years; they are larger and more rugged, and enable the generator to charge the battery with some relation to what it actually needs.

Speaking of the relatively small amount of current drained from the battery in starting, a normal start should not last more than 3 sec. and, in that time, an engine will turn over at least five or six times; this demands from the battery not more than $\frac{1}{8}$ amp-hr. The actual drain of current from a battery, which is vastly more important, is the lights, which may take 7 or 8 amp. and only have to burn for about 1 min. to take the same number of ampere-hours as is represented by an ordinary start. To replace the current which is used in making an ordinary start, a generator that provides 16 amp. need run for $\frac{1}{2}$ min. only.

A. D. T. LIBBY[6]:—I was in the telephone business for 15 or 16 years and designed a large number of power-plants in which we used two sets of 11 cells of storage battery. I have seen these batteries in operation under various conditions, and I know how easy it is for a battery to sulphate when it does not get the proper amount of charge. I agree with Mr. Ford that, considering the general average of batteries in all cars, they do not get sufficient charging. Much more trouble is brought about by undercharging than by overcharging batteries, and that leads us to inquire what constitutes the best means of charging a battery.

From what several of the speakers have said, the impression is conveyed that a constant-voltage generator is the proper thing to use for charging, the kind of generator that is able to feel the pulse of the battery and to act accordingly. The third-brush generator does not have those characteristics. That immediately raises the question as to why we do not use a voltage-regulator generator on our cars. In the beginning, it was not used because of the patent situation. When the patents committee of the Automotive Electrical Association was holding its first session about 1917 and while patents pertaining to generators were discussed, I prophesied that, while the voltage-regulator proposition was being fought over, the industry would use a third-brush generator. That is exactly what it did, and it was forced to do it. Now, after having been driven to its use, it has been found that the third-brush generator is very simple to make and gives, so far as the generator itself is concerned, very little trouble when the third brush is set at the proper place, and that is the point at which it will give the battery an overcharge rather than an undercharge. The second reason for not using a voltage-regulator generator is that it is more complicated and costs more. That immediately appeals to the purchasing agent of the car manufacturer; as a proposition of dollars and cents, he considers even the cents when he is buying for quantity production.

Regarding the statement made by Mr. Cook that the engineers of the car manufacturer are very careful about the battery which they specify, I have no doubt that this is true but I believe that the purchasing agent is not so careful. He is very apt to be reckless when it comes to the size of battery that he puts on a car. The Automotive Electrical Association, of which I have the honor to be president, has been, for the last 2 years, through its standards committee, working up specifications for lighting generators and starting motors. Those specifications have been printed in *Automotive Industries* and other journals. I advise automotive engineers to read those specifications.

The reason for the specifications is that we may know exactly what the generator and motor outputs are. That is done to minimize expense and prevent misunderstanding between the goods offered by the different electrical manufacturers; that is, it obviates having one company offer a generator of a certain size and another offer a smaller generator and claiming that the latter will do the same work as the other's larger machine. The same is true of starting motors and we hope that those specifications will be printed soon and put into the hands of car manufacturers and engineers, so that every electrical manufacturer can go in on the same basis and the pur-

[5] M.S.A.E.—Sprague Electric Works of General Electric Co., Bloomfield, N. J.

[6] M.S.A.E.—Patent attorney, Splitdorf Electrical Co., Newark, N. J.

chaser will know what he is buying. Also, with the co-operation of the battery men in that division of our Association, we hope to write a performance specification for a storage-battery. Some of the battery men say that this cannot be done, but others say that it can be done. Some day we will add that specification to our motor and generator specifications so that we can lay down to the car manufacturer, to the purchasing agent and to the engineer, a complete specification for a generator and a motor and a battery that will go on his car and give him satisfaction, thus eliminating much of the trouble that we have after the cars get out into the hands of private owners.

In connection with service on batteries and the matter mentioned by Mr. Cook of getting the car manufacturer to build the battery compartment or container sufficiently large so that, if the car-owner desires to install a larger battery, he can do so, I will cite an experience I had. I ordered a battery for my car from a battery company, and stated the model of the car; but within that year the car manufacturer had changed the size of battery and was now using a size larger than he had used the year this particular model of my car was turned out. Consequently, after the battery man had pulled out the old battery, he found that the new battery was ¾-in. too long for the space out of which the old one had come. How evidently foolish, then, it is, from a maintenance standpoint, to build a compartment that would not accommodate a battery ¾-in. longer.

The simplified practice committee of the Automotive Division, a movement which is being fostered by Mr. Hoover, is trying to get behind the S.A.E. Standards for battery sizes and to interest the car manufacturers in making the battery compartment of such dimensions that the car-owner can put in it a battery one size or possibly two sizes larger, if need be, without having to go to the trouble of cutting off the battery holding strap, drilling holes through the frame and moving the strap so as to admit the larger battery, as I had to do. I believe the car manufacturer gives no thought to this matter at present. He orders batteries just as small as possible and, after the car has been out a year in service, certain makes of battery begin to go to pieces. When the user wants a new battery, he asks for a larger battery than the one he has been using; then, he finds that he cannot put it on.

HENRY M. CRANE:—Within my experience, the battery is analogous to lubricating oil. I am thoroughly convinced that the manufacturers of lubricating oil know what is and what is not a good oil, but they have never seemed able, or at any rate willing, to tell how a first-class oil can be specified and how it can be tested, except by use. The battery, I think, is in much the same category. Without question the battery, when it is good, is a very remarkable piece of work. I know of two cars, both of the same make, one of which was bought second-hand in 1915 and now is probably approaching the junk pile. To the best of the knowledge of the present owner of that car, he is still using the original battery without its having had repairs. In the fall of 1916, a friend of mine bought a car of the same make, and his battery has never been repaired or touched in any way except for the necessary application of water. That shows what can be done with a storage-battery, and I think it is a very remarkable history, no matter how well the cars were taken care of.

From the battery user's viewpoint, I fully agree with the speaker who said that he had never seen an overcharged battery. All the troubles we ever had with batteries were due to not having a sufficiently active generator, and when we install on some cars generators that theoretically, by adding up the figures, would be sufficient to start and light two or three automobiles, then the batteries began to give good service, but only as long as the water was continuously supplied, and that means in summer as often as once a week. Without any question overcharging does tend to cause a battery to need a more frequent supply of water.

I would like to say a word to car designers in favor of providing a more accessible battery location. For a long time I was one of the guilty parties who mounted the battery under the floor of the rear compartment of passenger cars. It certainly looks very neat there from the outside, but it is a little hard to expect the driver who is busy driving the car most of the time to see that it does receive a proper amount of water; and that, evidently, from all testimony, is the most important thing that he can do toward the upkeep of the battery. In the last car that I designed, I put the battery in the right-hand fender near the rear end. I see that this is being done in some other cars, and it certainly appeals to me as being a step in the right direction. I am convinced that the owners will gladly relinquish some of the clean appearance of the outside of a car in favor of attaining greater accessibility for this very important unit.

QUESTION:—Is the use of constant-potential chargers advised by Mr. Cook?

T. R. COOK:—I would certainly advise constant-potential chargers if the apparatus can be built so that it can be maintained properly and without undue expense.

QUESTION:—Within the last year or two, what definite advance has been made in battery construction, measured in length of life or in output per pound of weight?

MR. COOK:—The output per pound of weight has been increased in the last 4 or 5 years between 15 and 20 per cent. Regarding length of life, the two things that have contributed greatly to the life of batteries have been a more uniform product on the part of the manufacturer and the exercising of considerably more care in the selection of the material that is used as an insulator between the plates. The practical results of this are hard to specify because, particularly in the last 3 years, smaller batteries have been placed on the cars. Any advantage of increased length of life that the manufacturer of the battery has attained has been more than compensated for by the decrease in size of the battery on the car.

QUESTION:—Why is the life of a battery so much shorter when used on motor trucks and motorbuses than when used on a passenger car? How can this be overcome?

MR. COOK:—I assume that question relates to service; that is, either the question of current input or the load that the battery has been put up against, or in the mechanical conditions under which it has been carried.

QUESTION:—Please discuss the drop in possible output with a decrease in the temperature of the battery.

MR. COOK:—The capacity of a lead-and-acid battery is approximately 50 per cent at 0 deg. fahr. The curve is very nearly a straight line from 80 deg. fahr. down to that point.

QUESTION:—Does the rate of output-drop vary with different batteries that have the same plate area?

MR. COOK:—Yes, in general, although the thickness of the plate would have some varying effect.

QUESTION:—What causes the greatest amount of trouble from difficult starting in winter?

MR. COOK:—Poor gasoline or poor carburetion, but the carbureter people have as difficult a problem as the battery people. When the automotive engineer picks out a battery, he usually considers the speed at which it will turn the engine over at 10 deg. fahr. and presumably has his carbureter and other apparatus adjusted so that the engine will start with that number of revolutions per minute. If the engine fails to start, the cause is difficult to determine. The failure is probably due to the battery or the ignition, provided the former is designed to turn the engine over at that speed.

QUESTION:—Have you any data showing the rate of cooling of batteries in atmosphere at a temperature of 0 deg. fahr.?

MR. COOK:—I have seen no exact data on that point; but, to get a battery down to a temperature of about 10 deg. fahr. throughout its contents requires about 12 hr. in an atmospheric temperature of 0 deg. fahr. I imagine that exact data would develop nearly a straight-line curve.

QUESTION:—Why does a plate buckle when a cell is filled to the proper level with water?

MR. COOK:—I believe that the water in the cell has not much to do with the ordinary buckling of the plate. Without exception the positive plate is the one that buckles. This may be due to poor manufacture; that is, altogether too much active material may be contained within the grid. Buckling is due to expansion. Expansion occurs because of the chemical change in the active material and due to heat; the active material expands more than the grid and, if insufficient room is provided inside the grid for the active material to expand, distortion of the plate results. The various inventors of storage-batteries have tried to hold the active material within a given space for the last 40 years, and they have not succeeded. Active material will burst anything that it is confined in when it is undergoing chemical change.

QUESTION:—Is a jelly-like battery-solution practical?

MR. COOK:—Jelly electrolyte has been used since about 1864. All the well-known battery companies have known about it; they all know what it will and will not do. I believe that it has no place in the starting and lighting battery, which is built to occupy a confined space. The idea is to get the greatest possible capacity. Jelly electrolyte undoubtedly reduces the capacity of the battery, other things being equal, because the present starting and lighting battery requires all the acid that can be poured into the battery space. When the discharging of a standard starting and lighting battery is finished, almost nothing but water is left. But if 20 or 30 per cent of that available volume is occupied with some substance that is not sulphuric acid, the battery is short of acid.

As to there being no necessity of filling with water, that is not true because water decomposes in jelly electrolyte exactly the same as it does in anything else. The effect is that, because you do not see the amount of liquid decreasing, you possibly deceive yourself into thinking that the battery does not need water, but careful examination will prove that it does. The upper portions of the plates may be absolutely uncovered, and the effect is the same as if the level of the ordinary electrolyte was at that point.

QUESTION:—Will ordinary city water injure a battery?

MR. COOK:—It depends upon the locality. In many cities the city water will not injure a battery. The water in Cleveland is good to use and I imagine it is good for that purpose in most Lake towns. In the interior, the water in many towns either contains considerable iron or other impurities, but principally iron, that make it very bad for use in a battery.

QUESTION:—What kinds of terminal will not become sulphated?

MR. COOK:—I know of no terminal that will not sulphate. The nearest approach to that is the old type of lead terminal, burned on the post and with the cable cast-in. That has been eliminated due to the desire to have a battery that can be removed more quickly from the car, and also to reduce the expense. With the old burned-in terminals, the cables were connected to a terminal block and they were bolted properly to it. It was absolutely the best construction, and still is today, but it costs a few cents more and, theoretically, it cannot be taken out as quickly.

QUESTION:—What can be done to get better battery boxes and better hold-down devices?

MR. COOK:—I am a very strong believer in the rubber battery-case and believe it has prevented considerable trouble in maintaining batteries. That is another instance in which it would be very desirable to have standard battery-sizes, because it would be very simple then to furnish rubber battery-cases. It is an impossibility to furnish rubber cases for the multitude of battery-sizes required to take care of the cars that are now running. I believe better hold-down devices can be secured. A clamp type of terminal, a hold-down that simply is screwed in against the side of the box and wedges it or holds it like a vise, is considerably better than the old type of hook over the handle or the box or putting something down on the top of the handle. Simply have a battery compartment so that one side can be forced in with a screw to the battery; it provides an ideal hold-down.

QUESTION:—Is it advisable to burn the lights when touring in the daytime, when the normal light-current draw is 10 amp. and the charging rate is 10 amp., presuming normal and usual operation of the car?

MR. COOK:—I believe it is advisable, when doing an excessive amount of touring. I have done this occasionally. After I have been driving for 6 or 7 hr. during the daytime, especially when it gets very hot in the afternoon, I decide that the battery is suffering just as I am; then, I turn the lights on and this relieves it somewhat. I think it does the battery no particular harm to fill it full of water. On a hot day, if you keep on charging the battery at 15 amp. when it needs no current, you will burn it out. Contrary to what has been said here, I have seen a battery that was burned up from excessive current. The covers looked as though they had been wrapped around a 5-in. pipe; the tops of the jars were all kinds of shape, they were buckled in and buckled out; the separators for the upper half were absolutely burned up and gone. A little evidence remained of a few separators between the plates at the bottom and not a drop of water was to be found in the battery clear down to the bottom of the jar. The only reason I could assign was overcharge. We examined the machine that the battery had been in and found it set to give about 35 amp. The owner had been out 6 weeks touring and had not given his battery a drop of water. How he got back, I do not know.

QUESTION:—What constitutes the principal difference between the high-grade battery and the battery made by the "gyp" battery-man who supplies the used-car dealer?

MR. COOK:—The batteries furnished by service-stations to used-car dealers are rental batteries that have

had half their life used up in rental service, and that is about the quality of the batteries that are purchased by used-car dealers. An 8-in. plate has normally say 0.34 or 0.35 lb. of active material that costs about 10.50 cents today. That active material can be reduced to half that amount if desired and it can be filled up with antimonial lead. It is a very easy thing to do. Incidentally, it makes a much easier grid to cast because the larger the bar in the grid is, the easier it is for almost anybody to cast grids; but it requires an expert to cast in a grid for a real battery. That is all right if you want a battery that has half the ordinary capacity and you can get away with it; but the battery will heat more and its life will be considerably shorter. I know that many "gyp" batteries are made of good plates. I do not know just how some batteries are made at the price they sell for, but I have not yet found a cheap battery that compares with the cheap batteries built by standard manufacturers in any way, shape or manner, either in capacity or in the elements that are responsible for the length of the useful life of the battery.

As to the necessity for holding a battery down, the inside of a battery is made of lead, and any severe jarring that causes a blow on the battery itself is bound to allow the lead parts to wear when they have any contact with other parts. For instance, if the bottom of a battery is hit continuously the rest will go right up through the plate. Lead will always flow under continuous blows of that kind, and a jumping blow like that of a battery jumping on a hard surface is very much harder on the battery than any vibration that it would get from either road or engine shocks. The truck-battery installation depends altogether upon the truck. Some trucks will get along very nicely with a battery held down by the handles, or preferably by the clamping device that I have mentioned, and I have seen cases where it is necessary to relieve the shock by putting some sort of a rubber shock-absorber under the battery, placing it under compression with a hold-down that will prevent any shock from reaching the battery itself.

EXPORT TRADE

IF we examine carefully the more alarming prophecies as to the dangers to our export trade from intensified European competition, we find that they proceed in almost every case from the assumption that the trade of the competitive areas has already reached a point of nearly complete saturation and that the issue is simply one of the relative strength of the leading contestants as to which will gain a predominant position. This totally erroneous deduction presumes a rigidity of the standards of living in these economically "new" lands overseas, which is so profoundly at variance with the actual conditions as to be almost absurd. If any one outstanding economic or social phenomenon has been demonstrated with irrefutable conviction throughout the world since 1918, it has been the truly astounding capacity of the human animal not only for recovery from the profoundest shocks, but for improvement and for aspiration toward higher levels of comfort and well being beyond any expectations of a decade or two ago.

The total import purchases of Latin America, Asia, Oceania and Africa were well over $6,000,000,000 last year, which was more than double the annual average of 1910 to 1913. Throughout Latin America we now have well over $3,000,000,000 of our capital engaged in reproductive enterprises, as against a little over $1,000,000,000 in 1913. This represents not simply a replacement of eliminated European investment but in numerous cases a direct contribution toward the development of hitherto untouched sources of wealth and well being, which has reacted profoundly upon the standard of living, upon the general social and economic outlook for great masses of population, and consequently upon their imports. In the competitive territories the requirements are in a large measure for those newer products of industrial ingenuity which have been the peculiar forte of American manufacturers, namely, moderately priced automobiles, motion-picture films, labor-saving machinery, ready-made clothing, electrical specialties, office equipment and similar lines.

Local industrial development will not only stimulate the importation of machinery and supplies but will directly improve the purchasing power of the native populations and thereby encourage the importation of a higher class of foreign wares, a development which will carry peculiar significance for the quality manufactures of the United States. Although the manufacturing industry of the United States had its decade of greatest growth from 1914 to 1923, the value of our imports of finished manufactures rose from an annual average of $389,000,000 in the 5 years 1909 to 1914 to $750,000,000 in 1924. We are now buying about seven times as much crude rubber as we did before the war, and some two or three times as much raw silk, vegetable oil, cacao, sugar and many other overseas raw materials.

The high rates of interest now being required by all lenders of capital to European enterprises will present an increasingly serious problem for the European manufacturer. He faces the inevitable burden of heavy tax-rates, from which relief may not be available for years. There is every indication of a steady upward climb of wage rates, which in Germany, for example, are still 25 per cent below pre-war purchasing power. With recovering exchange rates as a result of stabilized currencies, one of the monetary advantages enjoyed by our competitors after the war has been wiped out.

Long-term credits have a well-recognized place in all business, whether export or domestic. The difficulty lies in their proper administration; and in this field it might be well to dispose of the absurd fiction that American firms are amateurs in the matter of proper credit extension. For nearly two decades all sober-minded and well-informed European exporters have admitted the superiority of the long-time credit systems of such well-known American lines as agricultural implements, sewing machines and the like.

Let us adhere to those sound principles which have always been the basis of successful merchandising at home and abroad, good quality, just terms, implicit compliance with commitments on delivery and development of the best production technique. Let us, above all, keep our heads and not be stampeded by any sudden or momentary shift in the trade currents or by the temorary advantages of some of our competitors.—Julius Klein, Bureau of Foreign and Domestic Commerce.

Discussion of Papers at the Production Meeting

THE discussion of six of the papers presented at the Production Meeting held Oct. 22 to 24, 1924, at Detroit is printed herewith. The authors were afforded opportunity to submit written replies to points made in the discussion of their papers and as far as possible the discussers were given an opportunity to approve the stenographic report of their remarks before publication. For the convenience of the members, a brief abstract of each paper precedes the discussion, with a reference to the issue of THE JOURNAL in which the paper appeared, so that members who desire to refer to the complete text as originally printed and the illustrations that appeared in connection therewith can do so with the minimum of effort. The complete discussion of the Production Meeting papers, as given at the various sessions, has now been printed.

COINING-PRESS OPERATION

BY A. R. KELSO[1]

ABSTRACT

COINING-PRESS development is outlined and the author tells how such machinery was adapted to speed-up the production of automobile parts, such as forged arms and levers, by a squeezing process that superseded milling or spot-facing methods. The presses used are very rugged in construction and have the appearance of a plain-type punch-press, except for the knuckle that operates the ram. This knuckle is coupled to a crank by means of a connecting-rod or link. As the crank revolves, it straightens the knuckle. The pressure transmitted to the ram is many times greater than that which could be produced through a single-acting direct-connected crank-operated type of machine. An additional advantage of the knuckle movement is the application of pressure at the end of the downward stroke. The position of the ram at the end of the stroke is controlled by a screw-actuated wedge. Different sizes of press are made, ranging in pressure capacity from 100 to 2000 tons per sq. in. of area of the part squeezed.

Details are given of the squeezing operations and the percentages of increase in production over that attained under former methods are summarized. The composition of the dies is specified, and the application of feeding mechanisms to such presses is described.

Grain structure of the coin-pressed forgings was studied exhaustively and photo-micrographs are exhibited. Three specific conclusions were reached and these are stated.—[Printed in the November, 1924, issue of THE JOURNAL.]

THE DISCUSSION

EUGENE BOUTON[2]:—My interest in coin-press work is due to the fact that it decreases production cost so greatly. The fact that on close dimensions accuracy can be maintained as readily as on spot-facing or straddle-milling operations indicates that this method should be used more than it has been heretofore. Very few automotive plants have coin-press operations, and there seems to be but little knowledge of coining-press work. The supposition is prevalent that it is a crude operation that does not produce a good finish or maintain accuracy, and many production men are skeptical of the process in general.

Mr. Kelso did not explain the manner of holding the parts to be coined to the proper thickness. He spoke of ram adjustments for maintaining sizes. On certain kinds of metal some users of coining presses have found that having the dies come together at the extreme end of the stroke would maintain closer dimensions than would relying on the ram adjustment. As the dies are ground away, strips would be inserted to make up the difference. Have any means other than the ram adjustment been used to maintain accuracy?

A. R. KELSO:—The ram adjustment is wholly within the control of the operator. The faces of the dies are not allowed to come together. We have provided no steps whereby the dies are stopped; but, in selecting the equipment, we have installed machines that have at least 100 per cent greater capacity than the pressure required for the job. As an illustration of that, we had two connecting-rod forgings amalgamated in a press. Shortly after the feeding mechanism had been installed, the operator used a little more oil than was necessary in oiling-up; a film of oil had run down on to the surface of the upper die and, in flattening the first connecting-rod that had been fed through, the oil-film caused the rod to stick to the upper die in such a manner that it was lifted up with the stroke of the press. When the feeding mechanism put through another rod, the press came down on both rods and amalgamated them. The limits of size were found to be exactly the same as with a rod that went on through the press in the regular way.

A MEMBER:—I have seen such presses 7 or 8 years ago. About 1 year ago the White Motor Co. purchased one of about 1000-ton capacity. In all the shops in which I checked-up, I found that those who had tried the method thoroughly gave it up because they were not satisfied with the results. I wrote to Harry A. Schwartz, a Cleveland authority on malleable castings, and he is very much in favor of coin pressing if the right kind of casting is available. I see a great future for this type of press, just as Mr. Bouton does. Its elimination of scrap is one point that will do much to advance its progress, especially in shops of small size.

A. L. DELEEUW[3]:—When the limits are something like 0.003 in. or perhaps slightly less, I did not find it necessary for the dies to come together; but, when we tried to make cold forgings within limits of say 0.0005 in., we found it absolutely necessary that the dies come together. Even then we had some trouble due to oil, but in a somewhat different way. If a heavy oil is used and it comes

[1] Master mechanic, Hudson Motor Car Co., Detroit.

[2] M.S.A.E.—Supervisor of time study, Chandler Motor Car Co., Cleveland.

[3] Consulting engineer, New York City.

on the surface of the die, it may be found that the heavy 1000-ton coining-press does not produce sufficient pressure to compress that film of oil within the given tolerance. This illustrates perhaps better than anything else that a film of oil has thickness, a fact often forgotten by the machine designer.

The operation described by Mr. Kelso is really a modification of what is ordinarily called cold swaging. That is now done on smaller pieces to a very large extent. For example, a small geared heart-shaped cam used to be made in two pieces; later, we made it from a solid piece of steel. The first operation was to swage it down. The next operation was to trim it, because the metal naturally had to flow out in all directions. The third operation was to push it through a die to cut the gear teeth on it, and then it was given another trimming.

Another example of this kind is a half bobbin for a sewing machine. Originally, it was made in one piece on a screw machine; later, it was made in two pieces that were automatically welded together. The first operations were done in what is called an eyelet machine which made the piece up to a certain point, but it was minus a small hole and the top was still straight. Then it went through two swaging operations. The first swaging operation, which was to bring it down almost to perfect shape, required considerably less pressure than the second operation, which brought it down to final shape.

An important point is that, in all these operations, the pressure per square inch is not a constant; it varies with the thickness of the piece. Pieces such as Mr. Kelso has described are thick enough so that this point does not apply; but, for thinner pieces, the pressure per square inch increases enormously as the thickness of the piece decreases.

Specification of Coin-Press Capacity

Mr. Kelso spoke of 400 and of 800-ton presses. I have as yet been unable to find out what a 400-ton press is. I have asked many press makers as to what is meant by specifying, say, a 100-ton press, and all were honest enough to say that they did not know. The Society is in a position to standardize this matter if it insists on having the present makers specify what is meant, for instance, by saying "a 100-ton press."

When a press is driven by a crank or a toggle, the pressure is practically any amount desired. A small press which one can turn by hand would be able to produce a 1000-ton pressure at some point of the cycle. That point may be within an infinitesimal distance from the final axis, but, if there is no extension in the frame or compression in the bolster and lower parts there is practically an infinite amount of pressure on any machine. I think the press maker should tell us that he has, say, a 400-ton pressure when the crank or the toggle reaches a certain point. For instance, when the thickness of the piece is within 0.01 in. of the final thickness, let the pressure be 400 lb. or 400 tons or whatever it may be.

Toggles Versus Hydraulic Operation

There has been considerable discussion as to whether the hydraulic or the toggle press is the better one to use. Each has its peculiar advantages; those of the toggle press are obvious. On the largest presses, one can get, say, 20 strokes per min. but, with the best arrangements I have ever seen, we could not get more than about 5 or 6 strokes per min. on an hydraulic press. On the other hand, when embossing work on thin stock is to be done, such as coining, if you put in two pieces of stock the two pieces would not be amalgamated but they would disrupt the press. When a 1000-ton press is disrupted, it is a calamity, and such things have happened within my experience.

In one case a 1300-ton press was used for embossing a small piece, say 3 x 5 in., the design being sunk in the die about 0.012 in. deep. Oil that the operator did not discover entered the die, and when he put the second piece in, the 1300-ton press went to pieces. It was repaired at a cost of several thousand dollars; the operator repeated the mistake and the press was broken again. This illustrates the disadvantage of using the toggle-joint press for that class of work. I have suggested making a combination of the hydraulic and the toggle-joint press to obtain the advantages of the hydraulic press as to pressure and the advantages of the toggle-joint press as to the maximum number of strokes per minute. Instead of operating the toggle by a crank, the idea is to operate it from an hydraulic cylinder, which does not need to be very large. The pressure per square inch does not need to be very great. The strokes can be repeated very rapidly and the press could be made to be just about as fast as the ordinary mechanically operated toggle-joint press.

Mr. Kelso:—In my paper, I covered actual production only. We conducted research work some time ago along the lines Mr. DeLeeuw mentioned. Undoubtedly, a number of companies in heavy production have had considerable trouble with their clutch discs that are intended to be used in multiple. Several months ago, in checking-up, we found that the operating expense for a certain production required 14 men; 5 men were grinding the discs to a predetermined size and 9 men were straightening them by hand. So, very carefully, we put some of these clutch discs under an 800-ton press. We found that the press had not enough capacity to squeeze them to the required thickness; but that we could "flow" the metal just enough to straighten the discs. However, after we had determined what a sufficient pressure per square inch would be, we found that if the 800-ton press had been up to the 800-ton pressure specified by the manufacturer it would have done the whole work; but we find now that if we adopt the method we will be compelled to use a 1500-ton machine. If we decide to install a 1500-ton machine to handle all the clutch discs in our production, a saving of $2,247 per month will be made, and this will amortize the cost of the coining press in 1 year. That amount covers labor only; in addition, wheel upkeep on the surface grinding machines is $72 per day, so I think that the coining-press method of operation is worthy of serious consideration.

Chairman John Younger[4]:—Regarding the combined mechanical and hydraulic toggle-press, I saw a large briquetting machine in a certain roller-bearing plant recently that almost coin-presses scrap into a disc about 5 in. in diameter and about 4½ in. high. It has a safety valve so that the mechanical mechanism virtually is operated through hydraulic means. I was told that it is the first of its kind in this Country.

Multiple Coin-Pressing

Mr. DeLeeuw:—We have found that straightening can be done very well by a percussion press. It acts very rapidly, but to the best of my knowledge, no percussion press exists at present that is large enough for the clutch disc that Mr. Kelso mentioned. However, an hydraulic press would work very well and very rapidly on such work because, when the hydraulic press is used, the discs can be piled as high as desired and all straightened at

[4] M.S.A.E.—President and editor, *Automotive Abstracts*, Cleveland.

the same time. We tried that with other articles and it works well. In fact, instead of trying to speed-up the hydraulic press, I would advocate slowing it down somewhat and keeping the discs in position for a fraction of a minute.

Another application of the hydraulic press which speeds it up somewhat for embossing purposes is to have, say, three dies in tandem, a lower, a middle and an upper die. That is a very good plan if the production is great enough. The lower die carries the lower impression on its upper face. The middle die is located between the upper and the lower dies; it has the upper impression on its lower face and the lower impression on its upper face. The upper die carries the upper impression on its lower face. Two pieces of stock are inserted and, when the dies come together, both pieces are embossed at the same time. When the dies spread apart, a spring will hold the middle die from coming down. This idea can be carried out to any extent, provided the space in the hydraulic press is large enough and provided the production is great enough to justify the making of multiple dies.

MR. KELSO:—I have found, however, in straightening the discs I have mentioned, that it was necessary to displace or flow the metal before they would become straight. That being true, I fail to understand how it would be possible to stack a dozen or more discs on top of each other and expect them to stay straight when, due to the combined area they have, none of the metal has really flowed.

MR. BOUTON:—Some doubt as to the practicability of the coining-press method seems to exist. Seeing is believing, and I witnessed several machines in operation in the Hudson Motor Car Co. plant which were operating very successfully. Some of these presses were operating at the rate of 32 strokes per min., which is much faster than any milling or spot-facing operation and the limits were much closer. Those who have not witnessed coining presses in operation should visit the Hudson plant and see these machines turn out the work.

QUESTION:—Is it practicable to compress malleable iron?

MR. KELSO:—Our experience has been the same with malleable iron as with drop-forgings, except that we get a much higher finish with malleable iron than with steel. I know of no ferrous metal that cannot be coin-pressed, except some of the lighter alloys. The limits are determined by the amount of metal that is coin pressed. If the amount is increased more than 1/32 in., fractures will result.

QUESTION:—What heat-treatment was given the forgings prior to pressing?

MR. KELSO:—The specified heat-treatment. Connecting-rods were heat-treated before coin pressing just the same as they were heat-treated under the old method before machining. But we found that, with a long part such as a connecting-rod, which has a great distance between the two bosses, the old straightening operation was required after coin pressing just as the piece had to be straightened after milling when machined. The coin pressing is done while the part being pressed is cold.

LIMITS OF ACCURACY AND TOLERANCES

QUESTION:—What limits are practicable by this method?

MR. KELSO:—That depends entirely upon the specification. With an open die, the press can be held to a limit of 0.002 in. If a smaller limit is required, then the dies must be closed and should come together to a full seat.

CHAIRMAN YOUNGER:—Would you be able to hold a 2-in. deep connecting-rod to a limit of 0.002 in. with an open die?

MR. KELSO:—Yes.

CHAIRMAN YOUNGER:—What is the cost of the 400-ton coining press?

MR. KELSO:—About $8,000.

CHAIRMAN YOUNGER:—How many connecting-rods per hour can the magazine-type of coining press produce?

MR. KELSO:—Under the old milling-machine method, the best production we obtained was 117 pieces per hr. That production was immediately increased by the coining-press method to 294 pieces per hr., when the stock was fed by hand. After the mechanical automatic feed was installed, we averaged 433 pieces per hr., for more than 1 month of production.

CHAIRMAN YOUNGER:—Does heat-treatment after the coining-press operation change the size of the part?

MR. KELSO:—I presume it would change just as much as it would change the size after machining. More strains would be set up by coin pressing than by machining.

CHAIRMAN YOUNGER:—Have you tried to find out if coin pressing relieves any stresses?

MR. KELSO:—No.

CHAIRMAN YOUNGER:—Has any cold piercing been tried?

MR. KELSO:—No.

COIN-PRESS RESULTS FROM OTHER MEANS

QUESTION:—Has the question of obtaining coining-press results under a drop hammer been discussed?

MR. KELSO:—Yes, in an experiment with our clutch discs that we wished to straighten. We took some clutch discs in the rough to a company that owns the largest planishing hammers in the district, but the hammer would not even straighten the pieces. The metal must flow to straighten properly. To get the metal to flow, a pressure of 165,000 lb. per sq. in. is required, and that is probably 100 times in excess of any pressure that can be derived from the ordinary drop-hammer.

GEORGE L. MCCAIN[5]:—For parts that have been case-hardened, has the coining-press method been tried as a substitute for grinding?

MR. KELSO:—We have tried that on cyanide parts only; not on parts having a thick case. But it makes no difference, we can finish them. A cyanide finish has only a very thin case-hardened section. A heat-treated part would probably have a hardened case 1/32 in. thick.

CHAIRMAN YOUNGER:—I am informed that Harry A. Schwartz, manager of research for the National Malleable & Steel Castings Co., Cleveland, has covered the subject of the pressing of malleable iron in his latest book.

J. J. HARTLEY[6]:—Concerning coin-press methods, some 2 years ago we brought out a new type of clutch, which called for a very large quantity of forged levers, similar to a toggle link, about ½ in. thick by 3 in. long. We wanted the thickness of the two ends to be within limits of 0.001 in. and parallel. We had an 800-lb. drop-hammer that we used for straightening other work and, with very little trouble, we tried out the scheme of flattening the ends of these levers in this hammer, using two liners between two hardened-steel platens and fastening the liners so that they would remain between the blocks. We found that we could coin these pieces successfully within the required limits. Some difficulty was experienced in getting the maximum production within that close limit, and our engineers allowed another 0.001 in. Then we experimented regarding how many pieces we could put

[5] M.S.A.E.—Automotive engineer, Link Belt Co., Detroit.
[6] Factory manager, Borg & Beck Co., Chicago.

under the hammer and size at one drop. Finally, we were able to size six pieces, and have been doing that successfully for the past 15 months, at the maximum cost of 8 cents per 100 pieces. This eliminated the very costly operation of straddle milling, and the more costly operation of removing the burrs after milling. Likewise, it eliminated the expensive maintenance of milling cutters. We find we are getting very satisfactory results on forgings that vary from 0.015 to 0.020 in. as they come from the forgers.

Extruded Metal Due to Coin Pressing

HENRY J. HINDE[7]:—Regarding the extrusion of metals and the splendid adaptability of the knuckle-joint power-press for this purpose, this type of press is reasonably quick in its action and yet slow enough on the actual contact with the metal to allow it greater freedom in flowing; therefore, better results are accomplished.

The knuckle-joint press is now being extensively used for this purpose in the formation of certain articles from the brass rod or bar, in some instances the bar being as large as 3 in. or more in diameter, as well as in flat work and on brass castings, shapes or forms. The economy in production of the work is really wonderful, especially when it is considered that, in the extrusion process in particular, practically no more metal is required than actually exists in the finished stamping; thus, a saving in some instances of 70 per cent of the brass in the formation of the product is effected, as well as several hundred per cent saved in the labor cost in production.

Another feature is the marked improvement in the design of the knuckle-joint press of the present-day type. The construction of the knuckles in one type of press in particular is such as to give a very much greater wearing service at the knuckle joints than is found in the older types, or, in fact, in the many types of knuckle-joint press on the market.

Another feature in the construction of the knuckle-joint press of the make referred to is that the knuckles are now pulled in toward the solid-frame section of the slide-bearing, while, on many types, the knuckles are pushed toward the movable gib bearing of the slide. The improvement in question in this part of the construction of these machines all tends to increase the resistance to the greater pressures and the overload strains to which these machines are sometimes subjected.

TOOL DESIGNING FOR PRODUCTION MANUFACTURING

BY P. V. MILLER[8]

ABSTRACT

TO meet the increased demand for machined metal products, manufacturers of Machine-tools and cutting-tools have devised methods for greatly increasing the production of parts per man and per hour. Improvements in the tools and the materials have aided, but the greatest saving of time has been accomplished by improving the methods of holding the work during the machining operations. The most important points to be considered in the designing and the building of tools are discussed by the author, with special reference to the more common types of drill jigs and milling fixtures.

With the drill press, proper planning of the jigs and tools is essential and quick and easy handling of the work must be assured. The first thing to be considered in preparing a tool line-up is the locating of the work; but of equal importance with it is the system of holding or clamping the work in the jig. Here a study must be made to determine carefully the directions of the thrusts. The common method of securing or clamping is by means of a screw, with a nut and a hand-knob or a hand-wheel for putting pressure on the clamp. The cam type of clamp can be operated more rapidly than can the screw and nut, but it may be loosened by vibration. When the maximum pressure is desired to hold the work firmly in place the best style of clamp is one having a firm rest at the back and a suitable stud and nut between the work and the clamp-seat. When the space is limited, a direct-clamping screw, with the end resting on the work, may be satisfactory. If the pressure on the work is to be distributed among several points, rockers or equalizers may be provided. A clamp bearing on a flat surface of the work should have a suitable radius at the rear clamp-seat with a spherical seat under the nut or the washer to allow the clamp to float freely over the work. When the weight of the jigs is so great that they cannot be moved readily by hand, a suitable cradle should be provided to allow the jig to be turned to the different positions. Jigs and fixtures are differentiated by the author but the same general principles are said to apply to both.

When designing a fixture it is necessary to provide suitable keys or dowels for locating it accurately on the machine table. The cost of tools should be given careful consideration when planning operations and care should be taken that the design and the workmanship shall be of the best. If the final cost of production is dependent on the accuracy and efficiency of the tool, it is important that all unnecessary movements of the operator should be avoided.

Tolerance should have careful attention, for the effort of a toolmaker to work to unnecessarily close dimensions will mean needless expense. In plain-ground cylindrical or flat work, the minimum tolerance that should be allowed the toolmaker is 10 per cent of the working limits and twice this amount in the center distance between the drill-bushings. When production is not heavy and operation is intermittent, it is not economical to spend much money on tools, but whatever is built should be accurate and practical to operate.

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THE DISCUSSION

CHAIRMAN EUGENE BOUTON[9]:—Nothing was said about the swivel type of fixture. In instances where it is necessary to drill holes from two or more sides of the piece, what is your opinion of the swivel fixture that is mounted on trunnions so that the operator merely releases the latch and gives it a flop, compared to the method of turning the jig completely over on a table, on which chips might be lying?

P. V. MILLER:—Unquestionably the swivel type of fixture is a superior type where the quantity of parts to be manufactured warrants its cost for continued operation. In referring to the use of a cradle what I have in mind is the type of fixture that is used often for comparatively limited production, when the cost does not warrant as

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[8] Manager, small-tool department, Taft-Peirce Mfg. Co., Woonsocket, R. I.

[9] M.S.A.E.—Supervisor of time study, Chandler Motor Car Co., Cleveland.

elaborate a method as continuous production would require and when it is necessary, we will say, actually to make a simple box-jig and turn it over by an accessory cradle; that is, with jigs that have considerable weight.

GLENN MUFFLY[10]:—One factor worthy of consideration in the design of fixtures is to avoid stresses that distort the work when it is clamped in the fixtures. Tool designers sometimes pass this over as a negligible point when it is a serious matter.

ERIK OBERG[11]:—It is possible that the cost of the machine tools of the automotive industry is a comparatively small item compared to that for all the tooling equipment provided for the machine tools. Are any statistics available?

J. N. HEALD[12]:—I have noticed with regret how unevenly tool design and tool fixtures are distributed. I have seen factories in which expensive and elaborately fitted up automatic machines were in use in most departments but where, in the grinding department, old-style three-jaw chucks were used to hold the work. In one of the leading automobile factories in England, I saw a line of costly gear-generating machines. With great labor and expense, generating machines had been built that would form the gears to a curve that was ideal for quiet running. Those gears were sent from this gear-generating room to the heat-treating department and brought back to the grinding room to have the holes ground to size. It seems incredible but, after those gears came back from the heat-treating, they were held in a three-jaw chuck and trued-up with a piece of chalk. After all that effort to produce a perfectly formed curve, the labor was almost wasted by the means they adopted in the grinding operation to secure a true running gear. Quantity production has advanced greatly in the last few years. Tool designers in the factory are called upon continuously to design jigs and fixtures for lathes, drilling and milling machines and the like, but when grinding is needed, they seem to be helpless and to prefer to say to the grinding-machine manufacturer, "We would like to have a suggestion for holding this work on your machine." This is all right, but it causes the manufacturer added work and expense.

METHODS OF CHUCKING

MR. MUFFLY:—Transmission gears are commonly hardened and then brought to the grinding department to finish the holes. Three methods of chucking are employed on this operation; holding the work by its outside diameter, holding it by the so-called "pitch-line" method and chueking by the bottom diameter between the teeth.

The first is inaccurate because it depends upon the accuracy of roughing operations and because burrs will throw the work out of center. The second and more common method is incorrectly named, as a gear has no pitch line except when meshed with another gear, but the real trouble lies in the eccentricity that results from chucking by tooth surfaces. Teeth are distorted in hardening and some pairs of adjacent teeth are thus brought closer together while other pairs are tilted farther apart. The three jaws of the chuck are located by chance with the probability that one jaw will come between teeth that are tilted one way, and the other two jaws between pairs of teeth that are tilted the opposite way. The chance that all three pairs of teeth used for location will have been tilted the same way to the same amount of error is very remote.

If the teeth have been tilted together 0.001 in., the jaw between these teeth will enter about 0.002 in. less than its correct depth on a 14½-deg. pressure-angle. The error is less on a greater pressure-angle, but it is apt to be increased by the tilting of other chucking teeth in the opposite direction. The last of the three methods is the one I have found best on account of the fact that the bottom diameter is true with the hole and true with the average of the tooth surfaces. The circle of the bottom diameter is very slightly distorted, and this distortion is divided by two in chucking instead of being multiplied. The difference between these last two methods is clearly shown when gears are finished by grinding the teeth after the hole has been ground. We find that chucking by the bottom diameter allows a lighter grinding finish on the tooth surface than the common method of "pitch-line" chucking.

FACTORS THAT AFFECT ACCURACY

CHAIRMAN BOUTON:—So many gears are roughed by the hobbing process and finished by the shaping process that the distortion in the diameter of the gear is equally as great whether the gear is held at the root of the teeth or at the pitch line of the teeth. Many of the grinding-machine chucks equalize that when they grip the piece, which eliminates the same amount of the error in either method. I have heard that argued both ways as to which is the proper place to grip the gear, and I have heard some real logic on both sides.

EARLE BUCKINGHAM[13]:—Regarding tool design, the assumption has been made that the part-drawing to which the fixture designer must work is exactly what it ought to be. Such drawings may exist, but I have seen very few of them. I have tried to make some myself and it has always been very difficult. If the drawings are dimensioned exactly as they should be, that gives direct information as to how the piece should be held for each finishing operation. The effort is to make the tools and fixtures produce the dimension specified on the drawings. If they happen not to be the ones which the part actually requires, the labor sometimes goes for naught. Improper drawings cause at least 60 per cent of the changes which have to be made after production is under way, either in widening tolerances or in doctoring-up the fixtures to produce the required results.

In regard to the proper tolerances for the tools, a tool used to produce a large number of parts is one in which the accuracy built into the tool is reproduced many times; therefore, it is worthwhile to spend money to make it accurate. I think 10 per cent of the tolerance is a very good proportion, provided there is a certain minimum. If 0.0005-in. tolerance is specified for the work itself, I desire better than that tolerance for the tools. As to the tolerances on perishable tools, such as the small tools which are replaced many times in course of production, some of the manufacturing tolerance must necessarily be used for them.

CHAIRMAN BOUTON:—Many jigs and fixtures that can be designed to clamp the piece in the fixture with a cam arrangement or some simple sort of a clamp generally require one to screw up half a dozen nuts or bolts and to consume considerable time in getting the piece into the fixture. It appears that the tool designers have not considered that problem as thoroughly as they should.

A MEMBER:—Our practice is to make the locating points in the jigs fixed, so the operator cannot change them. We try to arrange all our locating spots so that they cannot be tampered with.

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[10] M.S.A.E.—Proprietor, Muffly Commercial Research Laboratory, Chicago.

[11] M.S.A.E.—Editor, *Machinery*, New York City.

[12] M.S.A.E.—Treasurer and general manager, Heald Machine Co., Worcester, Mass.

[13] M.S.A.E.—Engineer, Pratt & Whitney Co., Hartford, Conn.

The matter of clamping is perhaps one of the most vital but, as has been pointed out, it is many times overdone and the effect of the clamps is overlooked. In choosing the method of attack with any given problem, I think the locating points that are chosen on the piece and the method of holding the piece are the two fundamentals to be dealt with. In our work, we endeavor to make those locating points either on the side walls or the ceiling of the jig, so that they are self-cleaning, and to make clamping consist of not more than two operations, using handles fixed to the clamping members, whether they be cams or nuts.

CHAIRMAN BOUTON:—Relative to the locating points being made adjustable, some jigs and fixtures are designed that way but are afterward sealed-up so that it is impossible for the operator to make any adjustment; the tool department must make that adjustment. Is that the idea?

A MEMBER:—It is so that the jigs and fixtures will be fool-proof.

LOCATING AND GAGE POINTS

A. L. DELEEUW[14]:—Mr. Miller's paper gives general rules for tool design, one being to avoid such surfaces on the casting as the parting-lines of the flask. It may be very bad to make use of a parting line, but, in some cases, it may be very good to do so. For instance, if the particular piece were the boss on a lever and we desired to maintain the hole as exactly as possible in that boss, then we should use the parting line to locate the tool because, if we use the lower part or the upper part of the casting to locate it, all the variation lies in one of the two parts but, if we use the parting line, the variation is divided between the two parts.

Another general rule given was that we should use one gage-point only. Sometimes that is good and sometimes it is bad practice. Suppose we have to locate one hole and, to locate that hole, we have to start from say a milled or a planed portion. That locates the hole as correctly as possible. Then suppose that the other holes must have a certain relation to the first hole; in such case, we should use this particular hole as a gage point and, if there are then other milled surfaces that must be in particular relation to one of the secondary holes, we should use that secondary hole as a new gage point. Sometimes we get into trouble even when we try to do this, because it may be that the piece is designed and the dimension is given so that there must also be a certain fixed relation between the last milled surface and the first milled surface. What we have done, then, is not to design the jig wrong but to make the sequence of operations wrong. Such a general rule should include the proviso that, before the jig is designed, we must be absolutely certain that the sequence of operations is right and that it permits the avoidance of an accumulation of error.

GRINDING FIXTURES AND TOLERANCES

Mr. Heald is right that not enough attention is paid to grinding fixtures, at least in some shops. In one shop I was connected with we paid some attention to them, we assumed that when the piece came from the hardening department we simply had a piece of raw material. It had been machined but, having been hardened we could no longer depend on any dimensions, so we had to grind some particular surface and then use that as a gaging point for the other dimensions. Whatever way that gear has been made it was no longer the same thing after it came from the hardening department. What we may have had to do was probably, to grind the internal hole first and then it may have been necessary, in some cases to surface grind; then, we may have had to use that ground hole and put a piece in while we ground the teeth.

Regarding the tolerance that should be allowed the tool maker, suppose a piece in which the total possible tolerance is not more than 0.0005 in. between two points and the tool maker is allowed 10 per cent of that. Then comes the gage maker, or the inspector, perhaps, who must have measuring instruments to measure to within 0.00002 in. That carries accuracy too far. What we have to do is to make a fixture or a jig as exactly as possible to the dimensions specified, and then to measure it as exactly as we possibly can. For tools having tolerances of from 0.004 to 0.006 in., the rule of 10 per cent tolerance allowance to the tool maker applies very well.

PURPOSES AND COST OF FIXTURES

In many cases, entirely too much money is spent on jigs. The designer is apt to forget that there is only one thing he should consider; it is that the product must be good enough. A product can be good enough with a tolerance of 0.00025 in. or it may not be good enough with that amount of tolerance. We should aim to make the product good enough and no more. A very striking instance occurred during the war. A certain piece of material for a gun carriage had to have two holes drilled in it and a jig was made for these holes. The jig was produced by an outside manufacturer and it cost $600. About that time a new production officer took charge and he found that the holes were for the purpose of sticking a piece of leather through them. That jig for the drilling of those holes was more than good enough. We do not do that sort of thing to that extent very often, but we often are doing it to a somewhat less extent and wasting money.

Jigs and fixtures are made for two very distinct purposes; sometimes, for both purposes at the same time. One purpose is to produce quality, or accuracy; the other, to reduce the cost of manufacture. These two functions should be kept separate when considering the cost of a fixture. If a fine jig cost $100, it may be that in any case we would need to spend $90 because, without some-kind of a jig, we could not make the piece accurately enough; then we have added perhaps $10 to facilitate manufacture. The $90 is one matter and the $10 is an entirely different matter, and this should be kept in mind, but it is not always done. A certain sewing-machine company makes many varieties of sewing machines. Its trade often demands a new style of machine, but only a few hundred are needed. The company could not possibly make that new style of sewing machine and make it well unless its equipment included very accurate jigs and fixtures to produce the various pieces. The cost of such jigs is not counted in on the cost of manufacture; on the other hand, for other machines of which the company makes thousands a week, the money spent for facilities of operation constitutes by far the greater portion. The same situation prevails in the automotive field. When a tentative design is made, the tool engineer is immediately confronted with what must be done to produce the piece and, second, what must be done to reduce the cost.

CHAIRMAN BOUTON:—Regarding machine-tool costs, sometimes a standard machine-tool is bought and numerous tools, fixtures, jigs and the like are added to

[14] Consulting engineer, New York City.

this standard equipment. Is that more profitable than to buy a special machine?

MR. MILLER:—As to the cost of tool designing, we kept a record for about 1 year; it covered a general run of large automotive equipment, although fixtures and the like were included. The total cost of the designing was between 20 and 25 per cent of the total cost of the tool, on the average.

JOSEPH LANNEN[15]:—One tool designer who knows exactly what he wants and makes it will produce a certain quantity of work. To double that quantity of work, you hire three tool designers and put the first one in charge of them: and to double that quantity of work, you hire about nine tool designers and put two men in charge. In other words, to double the volume of work it is necessary approximately, to triple the number of men.

MR. BUCKINGHAM:—I once saw a fixture that required seven or eight clamps which had to be self-adjusted. They wanted to use the simplest means, so they filled a piece of rubber hose about half full of water and plugged the ends. The clamps all rested on the hose and had one clamp in the middle to squeeze it when they were ready to tighten up on the clamps. It made a very effective multiple-clamp.

THE GROUP WAGE-PAYMENT PLAN

BY H. G. PERKINS[16]

ABSTRACT

METHODS of wage payment that increase the incentive of employes produce more desirable results than the flat-rate or the day-rate method, the latter being unsatisfactory because it limits the earnings of an ambitious workman and does not assure the employer of a definite return for a definite wage paid. Piece-work is a development that bases remuneration on effort; in all methods of incentive wage-payment, the employe's effort is a measure of the pay check. Accuracy in the methods employed in pay-roll protection demands voluminous detail and is in direct proportion to the expense involved in maintaining the methods.

When faced with the alternative of increasing the expense of pay-roll protection or of discarding the system then in use, the Maxwell Motor Corporation decided to investigate the group wage-payment plan previously adopted by the General Motors Corporation. After it had been installed in two departments, this system was found to be very successful in one department but a failure in the other. This called attention to the fact that certain fundamental requirements are essential to success. These requirements are enumerated by the author, as are also the principles that ensure the best distribution of earnings among the members of a group. Adherence to these requirements and principles is said to have produced so spectacular results that the method has been made standard in all departments that are adaptable to group work.

Among the outstanding results of the system are great increase in productive efficiency, because the wages increase with the production; great interest among the men, because the spirit of teamwork is capitalized; labor costs have been lowered, because of the increased productivity; the standard of quality has been improved; the accuracy of production has increased with a decrease in the expense; fraudulent practices and overpayment have been overcome; the volume of scrap has been reduced, because the group receives credit only for the pieces finished and approved by an inspector and the number of rejections is diminished; the desirability of employment has been increased, consequently the labor turnover has been reduced; new men are broken in by the old ones more quickly, in order that the performance standard of the group may be maintained; productivity has been increased with less manpower; supervisors are kept more closely in touch with the performance of the various manufacturing units; efficiency figures show the comparative performance of each group in comparison with the standard performance established by the time-study department; and the weekly reports give, in addition to the efficiency figures, the day rate of pay, the actual earned rate, the number of men in the group, and the amount of the allowances. These reports enable the executive to get a very definite picture of the whole organization in a few moments. —[Printed in the November, 1924, issue of THE JOURNAL.]

THE DISCUSSION

N. G. SHIDLE[17]:—Mr. Perkins said that the establishment of the group system in the crankshaft department had been unsuccessful; later, he indicated that it had been successful in most other parts of the plant. Why could it not be applied to the crankshaft department? Why did it fail there?

H. G. PERKINS:—To be very sure of our ground we experimented simultaneously with two group methods that were based on different principles. The differential-case department used a method that we now use as standard. The crankshaft department used another method that we found violated a few of the fundamental principles. It was a distinct and separate method and was discontinued in favor of the other method.

MR. SHIDLE:—The difference, then, was in the methods and not in the departments?

MR. PERKINS:—Yes.

L. L. MITCHELL[18]:—How do you work the group bonus-system in the sand-blast and other divisions in which you make from 40 to 50 different parts?

MR. PERKINS:—The principles are the same. The details have to be adjusted to the work.

MR. MITCHELL:—I ask for the reason that we operate the gang system along somewhat the same principles as those of the group bonus-method.

MR. PERKINS:—It is a big subject. I suggest that Mr. Mitchell and I get together at a later date for detailed discussion to avoid too long an explanation at this time.

GROUP BONUS OR GROUP PIECE-WORK?

EUGENE BOUTON[19]:—Practically everyone agrees that the group method accomplishes considerable, but I should like to have an explanation of one point. What are the advantages of the group bonus-system over the group piece-work system? In other words, does not summing up the time that is required for a given unit require more clerical work than establishing a group price on that unit and pro-rating the men's earnings from that

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amount of money rather than from a period of time?

MR. PERKINS:—We tried a group piece-work plan. Our experience with that system was that it violated established principles. A just distribution of group earnings must be made to the individual group. With the piece-work plan, we found it much more difficult to recognize the fact that varying degrees of skill and ability are possessed by the different men than with the bonus plan. We found it much more difficult to distribute the group earnings on a just basis.

We attempted it in the crankshaft department and met with stubborn resistance from the workmen to the extent that every man walked out. Forty men laid down their tools and quit, refusing flatly to work on that basis because they did not like it. We had three or four pin-grinders who had been with us for very many years and were very accomplished men. They were worth almost twice as much to us as some other men in the same group on the same operation. We found it very difficult to distribute the group earnings in a way that would recognize that difference of ability.

We also found another very grave difficulty, which arose when we attempted to grant raises. At certain times men must have raises whether they are working on productive or non-productive labor. Increased ability must be recognized. When a man is given a raise, under the piece-work plan, the piece price does not increase; the total amount of earnings taken by the group is no greater, whether the man is working for 50 or for 60 cents an hour. Boiled down, it meant that, if a man were given a raise, it came out of the pockets of the other members of the group and was not paid by the corporation. We found no way to get around that fact successfully.

MR. BOUTON:—Under the group bonus-plan the men must earn the rates corresponding to various degrees of skill. Under the group piece-work plan you have the same thing, each man is rated according to his ability and the skill required to do a particular operation. Consequently, he draws a higher pro-rated share of the group earnings.

MR. PERKINS:—You are doing that to the penalty of the other members of the group.

MR. BOUTON:—They should be penalized if they are not earning their just proportion of the group wage. It is a leveling up, as I understand it. How do you know that the inspector gives a fair count, in other words, whether he "sells out"?

MR. PERKINS:—That phase of the wage-incentive plan is tied up with production control. The counts taken by the inspector are used not only as the basis of the pay-roll but as the basis of the production records. We take physical inventories periodically to check the accuracy of production counts. We found one very striking case of fraudulent count and have found cases of slight inaccuracy of count merely because the human element was involved. The production records, however, are the basis of the scheduling in our shops. They are very important records. They must be accurate and we take every means to safeguard them. The production record that gives a balance, when checked with the physical inventory made monthly, gives a pretty good check.

MR. BOUTON:—Do you take count of the stock when it goes into the department?

MR. PERKINS:—We schedule the shops on the basis of monthly production and the amount of materials required for assembling. We give the foreman the amount of material necessary to be worked-up during the month and show him the average rate per day that is necessary to maintain that rate of production. We give the stock-room the schedule and it makes daily issuance of raw materials to the first operation.

JOHN YOUNGER[20]:—Do you find the system flexible? If so, how do you apply it to automatic-screw-machine departments in which the speeds and the feeds of the machines are predetermined?

MR. PERKINS:—Yes, we apply it very successfully. In that work we have taken a formula, which I think was originated by Mr. Wennerlund, that recognizes the fact that a man at times operates one, two, three or four machines, and through that formula we establish what we call a coefficient of production.

MR. YOUNGER:—Is the bonus based on quality or on production?

MR. PERKINS:—We take scale counts of automatic parts and pay for the scale count of production, making rejections later, if defects run excessively high in the inspection.

JOB SETTING AND ALLOWANCES

E. N. SAWYER[21]:—How are the foremen and the tool-setters provided for in extra wages under the group plan?

MR. PERKINS:—Our so-called job-setters are members of the group. They are charged to the direct labor cost. They receive the same percentage of bonus as do the workmen of the group. We have not yet reached the point of paying the foremen themselves. It has received considerable discussion, however.

MR. SAWYER:—In case of tool and material troubles, how is the group paid?

MR. PERKINS:—Allowances are made.

MR. SAWYER:—Who makes the allowance?

MR. PERKINS:—The superintendent of the plant approves the allowance requested by the foreman. We have two kinds of allowance. Certain conditions may arise under which the group is operating that differ from standard conditions. The conditions are not those which existed when time-study was begun. They are operating, however, and are getting some production. We call that an operating allowance and charge it to direct labor.

MR. SAWYER:—Do you mean that you give the men a day's pay for a certain part of the day?

MR. PERKINS:—If they are operating under unsatisfactory conditions and standards, we give them an allowance that affects their efficiency. We have another set of conditions when the gang is absolutely idle. Under those conditions, we give them the day rate only. They are not operating, no production is secured on which costs can be applied, and the allowance is charged to the manufacturing overhead expense.

MR. YOUNGER:—Are the foremen paid straight salaries?

MR. PERKINS:—Yes.

CHAIRMAN E. K. WENNERLUND[22]:—How about the service department? You no doubt have a service department in which the machine parts are made?

MR. PERKINS:—Our service department is located at the Newcastle plant. As yet, we have not reached the point of installing group work in it. In fact, we have not completed the installation in the Chrysler plant although we began 2 years ago. We have five major plants. We still have some piece-work in the shops. I

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have not even made a study of that department and therefore cannot answer intelligently.

MR. MITCHELL:—We have about 8000 producers, 26 timekeepers and 4 men in the pay-roll department. Can you tell me how that checks with the percentage of pay-roll men to the number of employes in your system?

MR. PERKINS:—You have fewer than we have.

EQUALIZATION OF WAGES

MR. MITCHELL:—In your paper, you brought out the point that the veteran employes are entitled to a higher day-rate than are new employes. Do you believe in giving them a higher day-rate regardless of their ability?

MR. PERKINS:—The older employes would not have been with us so long a time if they did not have ability. We all know that the automobile business is seasonal. We all expand and contract the pay-rolls yearly. When the annual reduction is made and the men are put through the separator, we keep the cream. The labor turnover will remove some of the less efficient. The normal reductions and fluctuations in the force will remove others. In a general way at least, I can say that our old employes are the most efficient.

MR. MITCHELL:—That is very true, but if two men are working on the same line of work, performing the same operation, one of whom has been with you 4 years and the other 6 months, and the new man is turning out just as much work as is the older employe, do you think that the old employe is entitled to more money?

MR. PERKINS:—It is a question of judgment, in many cases; possibly not in the instance that you mention. We feel that a man who has been with us for 6 months is a member of our organization; but when the man is not a member of our organization and is looking for employment, the group method gives the management and the company a very decided advantage over the piece-work method. We can adjust ourselves to the prevailing labor situation very quickly. With the piece-work plan, we have an established cost. We cannot get under it in any way. But, with our plan, we can reduce the cost merely by taking advantage of the labor situation in the field and hiring men at lower rates.

MR. MITCHELL:—You made the statement that the executives are in position to have a more concrete and fundamental basis for knowing what the cost will be under the group bonus-system than under the piece-work system. Have you ever made a study of the gang system, the system under which the Hudson Motor Car Co. is operated?

MR. PERKINS:—I do not know much about that system.

MR. MITCHELL:—Under the gang system, we pay by the finished piece, that is, per axle or whatever unit is manufactured. Under the group system, are you in a position to furnish the executive with as good a report as to what the axle or the engine, or whatever it may be, will cost as can be done under the gang system? Under the gang system, all the cost department does is to total the price, and from that they can determine what the axle will cost. Under your system, you use a standard and work either above or below it. Is that right?

MR. PERKINS:—Yes.

EFFICIENCY AND COSTS

E. J. FROUNFELKER[23]:—And does this efficiency affect the cost?

MR. PERKINS:—Our costs are not affected seriously, as you might suppose, by the degree of efficiency. From 100 to 200 per cent efficiency and higher, our costs, when reduced to a per-piece basis are exactly the same. It does not cost us any more to operate at 175-per cent than at 100-per cent efficiency. We know what our standard costs are, regardless of the percentage of efficiency. We do not interpret the percentage of efficiency in the light of costs. It merely tells us whether the men are performing according to our standards.

MR. MITCHELL:—But you take the cost from the percentage of efficiency?

MR. PERKINS:—In a way, yes. Our standard is our cost.

MR. FROUNFELKER:—If your time-study is put into the form of standard time, what is the advantage of this over a piece-rate bonus-system?

MR. PERKINS:—We believe that the advantage is in the ease of the distribution of group earnings to the individuals of the group. The fact that the granting of raises is a penalty on other members of the group under the piece-work plan, was considered an advantage to the bonus plan.

MR. BOUTON:—The question of old and new employes is an important one in any plant. To have equal pay for equal work, which is the basis of all wage payment, some way must be found of rewarding an old employe and it should be done in some other manner than by a difference in rates. You say that you can reduce your rates by the large labor market, but you also have said that you guarantee your rates. Under a guarantee, how can you reduce the labor rates? If you can take advantage of reduced day-rates, you can reduce piece-rates in the same manner; your cost, therefore, is bound to be handled in the same manner.

MR. PERKINS:—The amount of money that goes into the pay-check is controlled by two elements: the day rate of pay that establishes a flat earning rate, and the percentage of efficiency that establishes the bonus; the two, combining, make the pay-check.

We guarantee time; in other words, if we tell a group that we will allow them 6 min. in which to do that job for 1 year, or until Oct. 1, or July 15, or whatever the date happens to be, that time will stand. We make absolutely no guarantee as to the day rate of pay. We feel that in that fact we have an advantage. You are familiar with the term "route-sheet." When a route-sheet is put into the shop on piece-work, a certain price is shown. When we put a route-sheet into the shop, it carries a time. When you want to adjust your costs to a declining labor market to make a saving, it is necessary for you to establish new piece-work prices. It is therefore necessary for you to recall those hundreds of route-sheets from the shop, write new ones, and reissue them with the new figures. We do not have to do that. A route-sheet goes into the shop and says that we will allow 6 min. for doing a job; that time stays until the end of the guarantee period, regardless of labor conditions. We may make adjustments in the day rates.

MR. BOUTON:—But the point you conveyed was that an employe was guaranteed his earnings.

MR. PERKINS:—I should not have given that impression.

MR. BOUTON:—His rate is guaranteed as to time, but not as to earning rate. Is that the point?

MR. PERKINS:—We guarantee the standard, which is time, for a definite period. The men may make 150-per cent efficiency, let us say. We guarantee that for 1 year, possibly. They make 150-per cent efficiency regardless of the conditions in the field, but they may make that 150-per cent efficiency on a 50-cent or a 60-cent day-rate.

[23] Continental Motors Corporation, Detroit.

MR. BOUTON:—Can the day rates be adjusted?

MR. PERKINS:—They are adjustable to the labor situation.

H. L. POPE[24]:—You say that you put only the time allowed on the operation sheet, for, say, a screw-machine job. You might have men in that department on an hourly rate of 65 or 70 or 80 cents. How do you know that the cost will always be the same on that piece, that is, the piece might take a 60-cent man and it might take a 70-cent man?

MR. PERKINS:—We establish standards of rate for the different classifications of work. The job is known as a 60, 70 or 75-cent job. That is called our base-rate. For each base-rate, there is a corresponding day-rate, which is lower.

MR. POPE:—That rate must go on the operation sheet or the foreman has to be notified in some way?

MR. PERKINS:—The route-sheet carries the base-rate that controls the day-rate and guides the employment office in setting day rates as men are hired. We have a committee, composed of the employment manager, the time-study man, the manager of production and myself, which revises the classification of base rates periodically.

SIZE OF GROUPS AND ADJUSTMENT

MR. YOUNGER:—Where do you get most of the suggestions regarding reducing the number of men in a group?

MR. PERKINS:—Only from the men. We do not ask them to reduce. The costs are the same to us; production is the same.

MR. YOUNGER:—The men come forward more than willingly to do that?

MR. PERKINS:—Yes.

E. W. SELLSTROM[25]:—Has any way been found of working the group bonus-method successfully on the toolroom and the die-makers? Do you apply it also to inspectors?

MR. PERKINS:—No. We have not found a way of applying it successfully to tool-makers or die-makers because the work is purely individual. We have not had the courage to attempt it. We do not feel that it would be successful. We do not put our inspectors on the incentive basis. We are opposed to the policy.

MR. SELLSTROM:—What do you do in the case of highly skilled men? How do you take care of tool-makers and die-makers? You know that a skilled mechanic can earn considerably more money than a tool-maker or a die-maker.

MR. PERKINS:—Our classification of rates includes non-productive as well as productive work. You will find the hand-drilling machine rate at 60 cents and that of tool-makers at possibly 90 cents. Tool-makers get a higher day-rate; most of them are working on a flat day-rate basis of about 90 cents to $1 per hr.

MR. SELLSTROM:—My thought then would be that the hand-drilling-machine men have more in their envelopes than the tool-makers.

MR. PERKINS:—That condition could exist. In fact, some of the departments have operated with such spectacular efficiency that we have had a condition somewhat parallel to that; but undoubtedly a 60-cent man is giving us considerably more effort for the money expended than is a 90-cent tool-maker.

MR. SAWYER:—At the end of the guarantee period do you let the whole crew go away? Do they quit or do they take the reduction in pay automatically?

MR. PERKINS:—We tell the men to make money while they can, "because we are coming down here in 3 or 4 months to look over this job and possibly cut it."

MR. SAWYER:—Do you succeed?

MR. PERKINS:—Absolutely.

E. L. SHEEHY[26]:—When one gang is working nights and another gang is working days, do you find any complications?

MR. PERKINS:—I think that is possibly the most annoying complication that we have in group work. In certain departments, it has been possible to keep the production of the day gang separate from that of the night gang. That is true in the enameling ovens, for instance, where we can put a marker on the carrier at the end of the day and let it carry through. The conveyor will tell, when the marker drops off at the end of the line, where the day and the night shifts began. In other departments, it is absolutely impossible to do so.

The night-shift and the day-shift men are made members of one group. We have found some degree of dissatisfaction, but we have overcome it to some degree by putting some of the best men on the night shift. We feel that, because of the advantages of the group method, we are willing to spend a little money to get those advantages and, in certain cases, we have paid some of the better men a special bonus for night-shift work.

MR. SHEEHY:—Is it not a known fact that the system operates better by having a higher class of help?

MR. PERKINS:—Any shop can operate better with high-class help.

MR. SHEEHY:—When all plants are working at the peak of production there will be a scarcity of men. The plants then will be flooded with inefficient help. Do you not think that a part of the high class men will limit themselves to the daily output of the inefficient men?

MR. PERKINS:—We have not had that experience. We find that the skilled men actually take an interest in bringing the other fellows up to the standard. Most working men are pretty good fellows. They like to help other fellows along.

MR. SHEEHY:—They will take that interest possibly until such a time as conditions are changed.

MR. PERKINS:—They will not carry another man if they feel that he is a penalty to them, but they will be tolerant with him until he has shown whether he is an efficient workman.

MR. SHEEHY:—As skilled men become scarcer and more unskilled men come in, what do you think the result will be then?

MR. PERKINS:—We have a flexible condition with which we take care of that. If we bring in less skilled men they come in at a lower rate. So long as they maintain 100-per cent efficiency the costs remain standard. It is a question whether an unskilled man will pull the group below the 100-per cent figure. In bringing them in at a lower rate, we are cutting the costs somewhat; we are getting below the standard. We have a little cushion to work on that we use to give the more skilled men a raise, possibly, of from 2 to 5 cents an hour, without increasing the cost in the least.

WHERE THE GROUP BONUS-SYSTEM IS USED

K. E. M. KARLSON[27]:—Do you use the group bonus-system in the final testing and final inspection? If so, is it satisfactory?

MR. PERKINS:—We use it in the final testing of an assembled car, in the block-testing rooms, in the final

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[26] Continental Motors Corporation, Detroit.

[27] M.S.A.E.—Factory manager, Cleveland Automobile Co., Cleveland.

assembling of the engine, in the assembling of the bodies and in the painting and trimming of bodies, but not in inspection. We have some drivers who, in a sense, are inspectors. They are working under this plan because they have rather definite jobs to perform.

D. H. STEWART[28]:—Has Mr. Perkins found any place in the Maxwell Motor Co. where he had to go from group bonus back to piece-work or to individual bonus? That question has often been asked and I have often been told that group bonus does not apply in some cases where piece-work does. Has Mr. Perkins met that situation at any time?

MR. PERKINS:—We have never given ground. If we decided to put the group bonus-method in, it went in. There are some places, such as the service machine-shop that was mentioned a short while ago, where we do not feel that group principles would apply, and we leave them alone because we do not think that we can improve conditions very much. We do not put the group bonus-system in just for the sake of having it installed. We install it only when we feel that we can get some results.

We have had some difficulty at times. We had a strike in the crankshaft department, when we operated on the group piece-work plan. We had great difficulty at Dayton with our first installation, because they had never heard of anything of the kind down there, and because the group work was installed simultaneously with the change from bucks to the conveyor in assembling the body, and in the paneling, door hanging, soldering and finishing work that always had been done on bucks. We put in the conveyor system simultaneously with the installation of the group system, and about 80 of the men struck.

We were unable to discover definitely whether they struck because of the different methods of manufacturing or because of the wage-payment plan; but the most voiced objection seemed to be against the conveyor. All those men are back now, however. They went out one day and came back the next.

Those two cases were our rebellions. They were the only two cases that we have had in the whole organization. We have approximately 400 groups. We have had petty difficulties and a great amount of discussion, which we welcome, because we have found that objection is usually based on ignorance of the methods and on lack of confidence in what we are doing. A campaign of education usually eliminates these difficulties.

MR. KARLSON:—Have you found any place in which the group bonus-system would not apply and in which you found later that piece-work would apply?

MR. PERKINS:—In no department where we attempted group work have we found that condition. There are departments in which we have not attempted it. I do not know what would happen if we attempted it with the tool-makers and the die-makers. We might have difficulty. Not having reached that point yet in our installation, I cannot speak from experience. All I can say is that, in every case in which we have attempted group work, it has been successfully installed.

C. A. LIPPINCOTT[29]:—How long has the plan been in operation?

MR. PERKINS:—We began it just 2 years ago.

MR. YOUNGER:—Has any bodily injury been done to a loafer by the men?

MR. PERKINS:—No; a good "razzing" usually gets "under his hide" about as effectively as anything else. We have had no violence. A man dislikes to be razzed. He would rather take a licking than have his fellow workmen razz him.

DISTRIBUTION OF BONUS AND HOURLY RATE

MR. KARLSON:—What percentage of what a man earns do you consider should be the bonus and what the guaranteed hourly rate? Some work on 20-per cent bonus but, from my experience, I have found that we must go a little higher than that on bonus and a little lower on the rate. For instance, if we are working on 20-per cent bonus, five-sixths of a man's wage is guaranteed and one-sixth is bonus. Sometimes we have found that it was better to make the guaranteed rate 75 per cent and the bonus 25 per cent.

MR. PERKINS:—Our policy on that, although not ironclad, is fairly well standardized. We feel that a high day-rate is desirable. We want employes that are of the right kind. We give them the bonus, not solely because it speeds-up production, but because it is a recognition of service. We want them to feel that our plant is a good place in which to work and that they will get a good rate of pay. We try to make the rate of pay a good average rate, whether they make any bonus or not. The bonus is merely an added incentive. We get back a saving in overhead because of increased production.

At the Newcastle plant, however, we have a very peculiar condition. A large element of the working force at that plant is recruited from the countryside. A great many men there seem to be well satisfied with a certain amount of money. They are not so ambitious as are the workmen in Detroit. Had we raised the day rates, it is possible that the men would have been satisfied with those rates and have been perfectly willing to let the bonus go. At that plant we thought it desirable, although we may have been wrong, to leave the day rates low and to make it easier to get the bonus. In some ways, we have made a mistake. In other ways, the plan has advantages, and we are still debating the question. In other words, we are experimenting.

MR. KARLSON:—Does the entire engine department work as one group or is it split up into smaller groups?

MR. PERKINS:—As a general rule, smaller groups are more effective. They establish a higher rate of efficiency more quickly. The men get to know one another better and are not concerned because some other fellow that they do not know or cannot see is dragged in. Our groups, as a rule, are not large. In some cases, they are large. In the engine assembly, for instance, we have a half-dozen sub-assembly groups. They are distinctly separate groups, all being paid for the finished engines, yet they are distinctly a unit.

MR. LIPPINCOTT:—About how many men are in the largest group?

MR. PERKINS:—Our final-assembly line, for instance, is pretty hard to split into groups; it contains, possibly, as many as 60 men. In some cases, as for instance in the brake-band group, the group consists of as few as three men. They are a little group by themselves. The average group is about ten.

RECTIFICATION OF ERROR

MR. SAWYER:—Does a group have to do remachining on its own time?

MR. PERKINS:—When a piece is inspected and rejected, the inspector determines the cause of the rejection. If it is due to faulty workmanship, he considers that the piece has not been finished, that it should not have come to him, and he puts it back into the line. When it comes

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[29] Manager, cooperative department, Studebaker Corporation of America, South Bend, Ind.

through in acceptable condition, he counts it as finished.

QUESTION:—In the machine shop, where a great quantity of foundry scrap is cast, is it not rather difficult with the group system to take care of the salary of the management as well as of the employe?

MR. PERKINS:—We recognize that employes are not responsible for rejections caused by defects for which the vendors are responsible. When we find a rejection of that character, we merely set it aside. At the end of the day, the salvage inspector looks it over and turns in a credit to the group for a certain number of pieces rejected in that operation. The timekeeper refers to the route-sheet and gives the men credit for a certain amount of time, just as if they had made good pieces. There is no complication. We find that it works all right.

QUESTION:—Do you use the time-study minutes up to certain operations?

MR. PERKINS:—The time-study sheet shows the time of each individual operation. We simply total them to secure the group time. We should be obliged to have the time of each operation, anyway, for pricing the inventory.

OVERTIME

MR. FROUNFELKER:—Do you give an extra bonus for overtime?

MR. PERKINS:—That is a matter of company policy. It has nothing to do with our particular wage-incentive plan. You will have that problem whether you are working by piece-work or day-work, group bonus or piece bonus. At times we have paid time and one-half for certain work. Our policy on that matter has shifted. I imagine that most factories go through a cycle of policies on that question.

CHAIRMAN WENNERLUND:—Mr. Perkins' paper is important because it shows a tendency in the automobile industry particularly, and in industry generally, toward the grouping of employees wherever it is practicable to do so. The grouping may be done by piece-work or standard time or any other wage-incentive system. A distinct tendency is apparent, particularly in this territory, toward grouping employees, because it finally works out well and cuts down clerical detail.

OTHER USERS OF THE GROUP BONUS SYSTEM

G. H. KLEINERT[20]:—The reason we adopted the group bonus-system about a year ago was to standardize production. In doing so, we made conditions to get in standard time and to eliminate overtime and other features of that kind. We are just getting nicely under way.

D. G. CLEMMER[21]:—We are installing the group bonus-plan in the Cadillac Company. So far, we are more than pleased with the results that have been obtained. Mr. Perkins' paper covers the plan of group bonus very thoroughly. One of the advantages to be derived from the group bonus-system that has not been brought out and that we consider very important is the saving of floor space. Take a plant the size of the Cadillac Motor Co. in which floor space is very valuable. We find, as we get into the group bonus-system, that the departments are not taking so much space as they did under individual effort. This is occasioned by the smaller quantity of material or flow in the departments. In other words, the group plan tends to increase production and, by increasing production, the material goes through the shop more quickly than it did before. The sequence of operations is much more rapid. It is not necessary to have a supply of stock ahead of each operation. That feature not only simplifies the amount of floor space utilized but also helps very much toward the handling of the material. We find that we are able to make a large saving in that one particular, irrespective of any other advantages. We are trying out the group bonus-system. In fact, it is working very satisfactorily, not only in our productive but also in our non-productive departments. The handling of stocks under the group bonus-system has proved very satisfactory. In some cases, we have reduced the amount of labor from 35 to 40 per cent. That means a decreased cost for handling the same amount of material. We have large departments working on the plan and, so far, are very well pleased in every way.

A MEMBER:—The men in the Cadillac shops are pretty well satisfied with the work in general. They are not earning so much money as under the piece-work system. However, the earnings are about the same in either case. At first, there was a feeling that they did not want to work for the other fellow. If they had an old man in the department, who was not so good a worker, they would like to get rid of him. I think that feeling has gone to some extent. We had to replace some old men. At the present time the system is working very satisfactorily. The men are well satisfied.

HARRY FORD[22]:—We have installed all the sweepers at the Cadillac plant under the bonus plan. We had a very large turnover on day work. It ran as high as 50 per cent. We have reduced that to the minimum at present, with a reduction of about 40 per cent in labor. The productive end speaks for itself. We are well satisfied with the amount we have saved.

CHAIRMAN WENNERLUND:—In the General Motors plants we are not so much interested in discussing the relative merits of piece-work or standard time; our subject is that of grouping. We are primarily installing the group idea. We are using standard time because we feel that that is a good way of doing it. Some persons might differ with us and prefer a piece-work basis.

I should like to make it a little clearer just why we use standard time instead of piece-work. Theoretically, it does not make much difference. We have a certain amount of money to divide and we find that you cannot very well divide the money equally. Some employes are older in the service, some are engaged on more difficult operations. Some difference should be made in the division. That is one reason why we use standard time.

MR. BOUTON:—In the Chandler plant, we have found that the group method is perhaps the best wage-incentive method in some operations, particularly in assembling, such as in the chassis and transmission groups. We have never experienced any particular difficulty in giving the proper pro-rated share of the earnings out of the group under the piece-work method. The employes are rated according to their occupation or classification. Some are highly skilled men who carry a higher rate than less skilled men.

The principal difference between the two systems, as I see it, is this: One uses a bonus method of computing earnings, the other, a flat rate. With group piece-work, the manufacturer knows exactly what the cost is. No bonuses or any variables whatever enter into it. The workman knows exactly what he will get and he knows it the next day after production, not a week later. He knows the next morning, before 8 or 10 o'clock, depending on the timekeeping department. So, it seems to me that the group piece-work system is ideal because everything is fixed; that is, the amount of work that is to be done for a given sum of money. Variations in rates can

[20] M.S.A.E.—Works manager, Kelsey Wheel Co., Inc., Detroit.
[21] Cadillac Motor Car Co., Detroit.
[22] Cadillac Motor Car Co., Detroit.

be adjusted in the same manner as under the group bonus-plan.

CHAIRMAN WENNERLUND:—You are grouping as much as you can, rather than using individual work; is that it?

MR. BOUTON:—Yes. A few operations are on individual piece-work, for example, some small lever that requires only the drilling of a hole; a man, perhaps, can drill as many holes in 1 day as would be needed for a week's production; we do not attempt to group that particular job. We leave it on individual piece-work. Large units, the machining and assembling of which require several men to complete the work, involve group piece-work. It has been found very satisfactory after 2 years of operation.

MR. MITCHELL:—My experience is somewhat the same as Mr. Bouton's. We operate our department on 100-per cent group piece-work. It has not only helped us to cut down the productive labor cost but has a great tendency to eliminate clerks, checkers, pay-roll men and comptometer operators.

During my 7 years' experience with the Hudson Motor Car Co., we have been operating under that system and have found it to be very satisfactory. We have met some snags such as you would meet in any system. The crankshaft department, particularly, was one that Mr. Perkins discussed. In the automobile trade, that is one of the hardest departments to control. It requires the highest skilled operators with the exception of the paint workers; but, after many complicated experiences, we have been able to include that gang with the other working units.

We had some difficulty the last year, when labor conditions were bad and men were hard to get, but the system itself we have found to be very satisfactory and are glad to recommend it, although we do not hold any hard feelings against the group bonus. We feel that they both are working toward the same incentive. I am 100-per cent in favor of the group system whether on bonus or piece-work. I believe that it is the ideal way.

A MEMBER:—About a year ago we began the group bonus-plan at the Cadillac plant. We had always worked by piece-work. We began it first in the assembling section. We were greatly surprised at the results. We got better results and found that the men liked it better; and the company certainly liked it better.

CHAIRMAN WENNERLUND:—The Cadillac Motor Car Co. was on an individual piece-work basis for years and had a very thorough checking-system. In adopting the policy of grouping, the company had an opportunity to choose and to investigate very carefully just what it wanted to do; it generally has a good reason for following a certain course.

MR. FORD:—I do not care to enter into a discussion of the relative merits of the group piece-work and the group bonus-methods, although we did consider both systems before we installed them. In arriving at the proper system for the Cadillac, we are always looking for the best. We found that we could properly pro-rate the earnings among the men better on the bonus system than on the piece-work system. Our principal reason for going into group rather than individual work was that we found considerable slack in the line in our assembling departments. We had individual operations and piece-work rates for each operation along the line. When a man had completed his particular operation, he generally was found sitting along the wall somewhere. At that time we were paying a full day's wage for the production. With the group-work system, we have taken all that slack out of the lines and have eliminated much clerical effort, such as individual piece-work tickets. At the time we began the group bonus-system, we had approximately 4000 of those tickets to make up and post on the pay-rolls daily. Along with that, we had the condition of a large number of day workers in the productive departments. In installing the group system, we have eliminated day workers entirely. The only man in any of the group departments that works on an individual rate is the foreman. The assistant foreman and job-setters have been placed in the group. In doing so, we found certain departments that were overloaded with supervision. We reduced that item when we put the men on bonus.

Outside the productive end, we found that most of the non-productive departments were between 50 and 75 per cent efficient. The number of men on the loading dock was decreased nearly 50 per cent. We have not gone very far with the bonus system, although we have installed it in between 50 and 60 per cent of the departments. At present, we have the assembling and shipping departments and several of the major jobs in the plant in line. The crankshaft department, with which Mr. Perkins had difficulty and of which Mr. Mitchell spoke, will be the subject of our next attempt at the Cadillac plant. We expect to have the grouping of the entire plant completed within the next year.

MR. YOUNGER:—At one time I was operating a plant under the group system. We had a complication between two Italians. One accused the other of being a loafer. Some violent language was exchanged, and one fellow laid the other out with a monkey-wrench. I have heard that sometimes the system does lead to violence among the men and that is the reason I asked the question. It might interest you to know that the widow of the man who was killed sued the company and was awarded $5,000.

MR. SHEEHY:—We have thoroughly installed the complete group piece-work system in the Continental Motors Co. and have gone possibly a little bit farther than the Hudson Motor Car Co. in paying every department in the plant from the final assembling line down. In other words, we have moved the time of payment for the finishing of the material back a little farther than by paying as the material leaves the department. We have made wonderful strides in reducing the number of hours required for the completion of the engine, have eliminated a great quantity of scrap, have increased the earnings of the men and have complete satisfaction in the organization. I am of the personal opinion, however, that when all companies get to operating under the same system, as they are gradually beginning to do, dissatisfaction will be found among the men and, when the plants get into high production, so that the men can get what they want, they will force the companies to revert to the individual piece-work system.

CHAIRMAN WENNERLUND:—Are you using group piece-work or group bonus?

MR. SHEEHY:—We are using group piece-work.

MR. KARLSON:—I have always believed in rewarding individual effort. I have always believed in working hard and getting something for it. Two years ago I heard Mr. Wennerlund's paper and was very glad that the subject came up. It was an inspiration. Although we have not used the system that he outlined I got some good points out of it. In our plant we are using group piece-work. So far as I can see, although our conditions are peculiar, I believe that it is the best for us. Yet the group bonus-system has many merits.

L. S. CARTER[23]:—From an accounting standpoint, so far as we have gone into it, I think the group bonus-

[23] Cadillac Motor Car Co., Detroit.

system makes a very clean-cut method of procedure for pay-roll work and for cost work as well. We can shorten our method of arriving at assembling costs by using a group price for a domestic assembly. We know that we shall have to go back to the standard time for each operation to determine parts costs, but, for arriving at the cost quickly, the group bonus-method will help greatly. So far as we can see, we are very much impressed with it and hope to see it progress with great rapidity in the Cadillac plant.

CAUSES OF SURFACE CHECKS IN WOOD IN VARNISH-DRYING ROOMS

BY HARRY D. TIEMANN[34]

ABSTRACT

PECULIARLY complex in its cellular structure, wood is subject to deformation that accompanies changes in its moisture content which is neither uniform nor isometric. Generally, deformation is about fifty times as great in the radial direction of the log as longitudinally, and about twice as great circumferentially as radially; so, when moisture changes occur due to changes in the degree of humidity of the surrounding air, the behavior of wood is very uncertain. Conditions are complicated further by the manner in which drying takes place.

A description is given of how water is contained in wood, including details of wood structure, and the action of moisture in causing swelling and subsequent shrinkage is discussed. The fiber-saturation point marks the limit to the amount of moisture that can enter between the fibrils, at which limit swelling ceases. It is determined by making endwise compression tests on a series of small blocks of the wood, as its drying proceeds. Water is, therefore, contained in wood as hygroscopic moisture adsorbed in the cell walls and as free-water occurring in the capillary spaces, with the fiber-saturation point as the division line between the two conditions.

In describing how wood dries, "set" and "casehardening" are explained, since the problem of the dry-kiln engineer is to control these drying stresses so that the wood shall suffer no serious injury. When drying a green stick of wood in air or in the kiln, surface checks will at first tend to open up as a result of the tensile stress in the outer surface. But when the reversal of stress takes place as the drying proceeds, these surface checks will close up again and may even pinch tightly together by reason of the compression of the "set" surface. They may become invisible, even when the lumber is planed. What happens when dry wood having these incipient but invisible surface checks is placed in a varnish-drying room that has a high relative humidity and a high temperature is set forth, and three specific causes of varnish-drying trouble are stated.—[Printed in the November, 1924, issue of THE JOURNAL.]

THE DISCUSSION

G. E. FRENCH:—Would a preliminary coat of oil prevent checking?

H. L. TIEMANN:—We have made a great many tests at the laboratory as to the effectiveness of different coatings in the prevention of absorption of moisture from the air and found that ordinary linseed oil and even spar varnish do not prevent the absorption of the moisture. They will retard the actual taking up of water, that is, if water is splashed on it will not soak in so quickly. Wood coated with linseed oil will take in the moisture from the atmosphere almost the same as the uncoated wood. Certain coatings, however, will largely prevent the absorption of moisture.

L. H. CUTTEN:—Will it be necessary to regulate the humidity in both the wood-shop and the varnish room or can a compromise be made between the wood-shop and varnish room?

MR. TIEMANN:—It may seem rather impracticable to advocate the control of humidity in wood-shops but I think in the long run a certain amount of control is highly desirable. This has been found to be true in delicate instruments, such as propellers manufactured for airplanes, for example. It is very essential therefore that you have the humidity in the room accurately controlled. Accurate control of humidity would not apply to the automobile body-shops, but I am inclined to think that an approximate control is desirable. In winter, when you have steam heat on in the factories, you are likely to have an excessively dry condition, perhaps down to 20-per cent humidity. In summer, when the temperature is up to 80 or 90 deg., all the heat is turned off at the factory and you get nearly a completely saturated condition at times. It would be desirable for a woodworking factory of that kind to have some heat on during the summer. I do not know how you could work that out for the good of the workmen; it would be a difficult thing to manage. If you could supply some heat so as to raise the temperature 5 or 10 deg. above that out of doors, it would be very desirable. It might not be necessary to do it through all of the processes, but wherever the lumber will remain for a day or two some heat should be applied in the summer and a slight amount of humidity added in some way during the winter.

W. M. PHILLIPS:—Has any one used amylacetate?

MR. TIEMANN:—Amylacetate or turpentine will not affect the wood to any appreciable extent. I do not think either can be taken into consideration at all with the varnish, however.

EFFECT OF PRESERVATIVE COATINGS IN THE PAINT DRYING-ROOM

CHAIRMAN GEORGE J. MERCER:—I understand that a process is available for preserving the wood during the time the bodies are in the drying-rooms. We have trouble not only in the checking of the wood that is exposed but, when the bodies are subjected to from 200 to nearly 300 deg. of heat during their paint-drying process the joints will dry out and the glue in the joints is destroyed. I understand a method has been devised whereby the wood is protected; that is, it is coated so that the joints are protected and the wood is left in its normal condition and remains in about the same condition during this heating process.

MR. TIEMANN:—I cannot answer that from personal experience. I understand that most of the varnish manufacturers now make a preparation that they claim will prevent evaporation of the moisture during that process. How efficacious it is I do not know, but, I think it is not very effective as a general proposition. Mr. Dunlap, of the Forest Products Laboratory, has been making a great many studies of the protective effects of different var-

[34] Dry-kiln expert, Forest Products Laboratory, Madison, Wis.

nishes and coatings. The majority are not very protective. If the calls are sufficient, I think possibly the Laboratory might some day start a series of experiments on these particular protective coatings. Our information at present is very incomplete.

A. I. STEVENS[35]:—Possibly I can assist in answering the question just asked, being the originator of that method. Much of our research was based on the work of the Forest Products Laboratory and one line in one of its reports on wood treatment was the cue that led to what we did. The process, which is probably the one to which reference is made, has been in successful use by one of the large production companies for about 3 years. We do not claim that it *absolutely* prevents taking up moisture or distortion of the wood frame. We claim that it so retards it during the period that the body is under heat while being baked that the moisture-content will remain constant.

Another cue that we obtained from the Laboratory was the theory it laid down that the *constancy* of the moisture-content and not the *amount of the content* is the essential thing. This method reduces the moisture-content to about 3½ per cent; that is, using temperatures up to 375 deg. in baking the finish on the body. During the ½ hr. that the body is at that temperature, the coatings gradually allow moisture in excess of 3½ per cent to leave and the coating seals itself during that same heat so that practically no more moisture will enter; but one of the difficulties faced has been to induce the companies producing bodies under this method to coat the ends of each piece and to put a uniform coating over all parts of the body. A great many automobile companies want to buy the finished body, at least in the white. Then the difficulty presents itself of coating the wooden frame at those points where it is in close contact with a panel, and that has caused considerable trouble. It is very desirable either to get the wood before it is assembled into a frame, or the frame before it has been paneled, and to coat all surfaces. That leaves the moisture-content practically constant but does not absolutely prevent moisture entering, although it is very difficult for it to enter.

MR. TIEMANN:—I might add in explanation that it would not be necessary to prevent the absorption or the loss of moisture entirely. If you can retard the rate of that loss and absorption you will have accomplished considerable toward solving the difficulty, because that effect is produced by the suddenness in the gradient of the moisture-content at two different points or two different layers in the wood. If the moisture drops suddenly from one zone to the next, you will get excessive stresses, but if the moisture drop is gradual through very smooth curves, those stresses will be minimized. So, if you can get a coating that will retard the interchange of moisture sufficiently, it will accomplish almost the ideal result.

MR. STEVENS:—Our work along this line proceeded for more than a year before anything was placed before the public, and absolutely confirmed the last statement. We tried to make the protective coating absolute but failed in doing it; there is no question about it, we could not do it, but we did do this: and I neglected to mention before that the particular method we recommend contemplates about 4½ to 5 hr. in the treatment of the wood before the metal and paneling are put on, which accomplishes the gradual treatment of the wood exactly as has been described here. Our work has been singularly confirmatory of what has been done at the Forest Products Laboratory.

MR. CUTTEN:—How are we to avoid trouble in the varnish-drying room? The ideal condition of the varnish-drying room is an 80 deg. fahr. temperature and 35 to 40 per cent relative humidity, while the humidity of the wood-shop may be anywhere from 20 per cent at 70 deg. fahr. in winter to saturated at various temperatures in summer. The only answer seems to be air conditioning in the wood-shop.

MR. TIEMANN:—I think Mr. Stevens has the solution to that problem. One solution is to put on a coating that will retard the transfer of moisture. The other solution would be to regulate the humidity in the wood-working shop. It is highly desirable to regulate the humidity in the manufacturing department. Too little attention has been paid to that phase of the whole subject in the automobile business and especially in the furniture business.

LINSEED OIL HAS LITTLE EFFECT

A. E. CORBIN[36]:—The statement was made by Mr. Tiemann that linseed oil or varnish did not retard absorption, and I take it that the converse was also found to be true, according to the moisture-content in the air, that it would not retard the giving up of moisture if moisture was lacking at higher temperatures. Were the results determined with the fresh application of the linseed oil or varnish or after the coating had become oxidized and set; dried, in other words?

MR. TIEMANN:—Those experiments were made, I think, in both ways, while the coating was moist and after it was dried. The question often comes up whether painting with linseed-oil paints will improve this condition. Undoubtedly, when a pigment is mixed with the linseed oil, the rate at which the moisture is absorbed in the wood is considerably retarded and beneficial results are brought about by this slight retardation, so an oxidized coating of linseed oil probably does retard it to a certain extent. I did not mean to say that it would make no difference, it will retard it slightly, but the effect of pure linseed oil is very slight.

MR. CORBIN:—Many things are to be learned along the line of consecutive coatings also, but it has been the practical experience of our organization during 8 years in the drying of paints that the relative humidity in the air conforms closely to at least a part of the scale which Mr. Tiemann has found in his separate investigations, and in several installations we have found that the manufacturers have done away with relative humidity in their drying-rooms to their cost and have put it back to hold the stability of their product on the basis that Mr. Tiemann has outlined. We do not go so high in our relative humidity as 60 per cent, but then we work with lower temperatures than 212 deg. fahr.

A point that has not been brought out is the rapid oxidation of the paint. Investigation has been made only in relation to the wood, and the accomplishment from that standpoint has been rather remarkable because we find that in the majority of cases, when a coating of paint dries in a certain time, it can be dried in one-eighth of the time by the proper balance of temperature and humidity. We have also found that if the manufacturer desires to hasten production and starts at the finished varnish end, using only finished processes, when he actually considers that the varnish may be a 48-hr. or longer varnish but sees the opportunity to dry it in 6 hr., the results are very unsatisfactory. It is much better, if only part of the process is to be handled on that basis, to start with the rough coats.

Another thing we have found in the refinishing of air-dried-lumber products, is that the coatings of paint that

[35] M.S.A.E.—Secretary, Oxford Varnish Corporation, Detroit.
[36] M.S.A.E.—Sales department, A. S. Nichols Co., New York City.

are on the wood do not seem to affect it at all. For example, it may have had a balance of 15 per cent of the moisture-content, whereas, if a process of controlled drying-on of the paint is undertaken on that air-dried lumber, without preliminary drying, it would bring the content down to about 7 per cent and you get very bad results; so, you must start in the rough. I was speaking of the sealer coats on air-dried lumber that has 15-per cent moisture-content and that has been out for a year and comes in for a refinish, as it does in many street railway shops or from motorbus lines. That takes a rapid drying apparently without any apparent checking. Perhaps the checks are all covered by the paint in the first place, but we have very good success with such jobs; whereas, on the new lumber, it is necessary to start from the rough end of the painting and hold down the temperature and humidity, balanced as in the lower end of Mr. Tiemann's schedule.

B. NAGELVOORT:—We made some attempt to maintain a balanced condition for the wood during the drying process of the paint, as indicated by the chart Mr. Tiemann showed, but found that in one case we had to discontinue it because it destroyed the paint. When we maintained the balanced condition the paint fagged; so, you have to strike a happy medium, because it is the paint you are considering in the paint-shop and you cannot do everything in favor of the wood.

CHAIRMAN MERCER:—It is a very common belief that the best preservative for wood is linseed oil and generally when a frame is first set-up, if it has to be exposed to the weather, it is customary to coat it with oil. I would like to ask Mr. Tiemann if other preservatives are better. Have you made a test with other coatings that would be preferable to the oil?

MR. TIEMANN:—You mean before any varnish has been put on?

CHAIRMAN MERCER:—Yes, the initial cost.

MR. TIEMANN:—It has been accepted generally, I think, throughout the paint trade and also by builders when varnishing the outside of frames of houses, that the best protection for the wood was a coating of boiled linseed oil. It is not at all a preservative in the sense of being an antiseptic to fungus attack. It does, however, slightly retard the alternation of moisture on the surface, reducing the tendency to compression checks. In that respect the linseed oil is slightly beneficial, but I think its preservative effect has been very much exaggerated. It hardly prevents the absorption of moisture by an appreciable amount. I refer to the ultimate absorption of moisture upon exposure to the air. I believe that many other coatings are much more preservative so long as they will cling to the wood. Of course, amylacetate solutions of nitro-cellulose or such substances are different.

CHAIRMAN MERCER:—The oil is not enough of a sealer, is it?

MR. TIEMANN:—Oil is not a sealer, it is very porous to moisture, but popular opinion has been strong in regard to the action of linseed oil for which we can find no basis. It keeps out the dirt, of course, and keeps splashings of water or anything of that kind from injuring the wood.

CHAIRMAN MERCER:—It makes an elastic foundation for the aftercoats.

Mr. Tiemann:—That probably has very much to do with it. The Laboratory never has made any studies of paints and varnishes. When it comes to a discussion of paints from the standpoint of the physical behavior of the coatings, I do not feel myself qualified to speak on the subject.

MR. STEVENS:—Work along that line brought to our attention the fact that an oil which might be used for a preservation of that kind, but which penetrated too much, defeated its own purpose. I have seen kitchen floors of maple treated with successive coats of linseed oil, put on hot with a swab. The floor would finally take on a polish that the scrubbing brush or almost any kind of scrubbing solution would not affect at all. The finish would come back up with a soft luster and the wood was absolutely preserved. That led us to believe that penetration was the thing desired, and several months of our work were absolutely wasted along that line. We found that linseed oil was a rank failure for automobile work, but we also discovered that some combination of oils which would form a shell and stay on the outside surface of that wood was what was wanted.

FEW ACIDS IN WOOD

L. L. WILLIAMS:—Is the moisture that has been spoken of added moisture or is it the free moisture that is in the green stock? Further, is the acid that is in the lumber, which is completely removed by proper drying, the residue that we find in improperly-dried lumber? If so, is it necessary to penetrate the lumber at all by an application of any kind of preservative? After all this acid is removed, can the lumber take on free moisture, regardless of what change will take place? It will act as a sponge, will it not? It will take moisture and it can be relieved of it without tearing-up the texture of the stock.

MR. TIEMANN:—I think you are working under a slight misapprehension as to the materials that are in the wood and as to the acidity. Probably no appreciable change occurs in the chemical materials in the wood due to the removal of the moisture. Most woods contain very few acids. Certain species contain some acid, as chestnut, for example, and a slight amount is found in oak, but it has nothing to do with the ability of the wood to take-on moisture from the air or lose moisture. No ordinary treatment of the wood changes that property which we call hygroscopicity. The wood will continue to absorb and lose moisture indefinitely with the changing humidity of the air. It is a property of the wood substance itself.

MR. WILLIAMS:—You have completely disturbed me. I have never heard that before. I have always believed that a residue was left clinging to the lumber after the drying process. I believe that others feel as I do.

MR. TIEMANN:—That the residue is the cause of the hygroscopicity in the lumber is not the case.

MR. WILLIAMS:—Does that not differ from statements that have been issued until recently?

MR. TIEMANN:—The idea as to the efficacy of steaming lumber, for instance, in removing the so-called proteins and acids in the lumber has been very popular. As a matter of fact, little or no action of this kind occurs. A possibility exists that the process will hydrolize some of the starches into sugar and render them soluble, but the effect on the lumber is practically nil; you cannot trace it. The popular idea of getting the sap out of the lumber so that it will hold its shape better is altogether fictitious. No removal of any of the chemical substances, except volatile materials, from a piece of white oak, for example, occurs in drying. Those substances are sealed up inside of the wood just as effectively as though they were canned in a tin.

No appreciable change takes place in them. The moisture passes off and they are still there. It is possible that you may be able by soaking to leach out from the sapwood some of the carbohydrates and acids that it contains, chiefly, sugars, but this leaching does not produce

the relatively high results that it is often alleged to, and it affects the sapwood only. Generalizing on this particular subject is somewhat dangerous because it is very complicated. Certain substances, notably sugar, seem to affect the shrinkage of the wood slightly. You can take a piece of wood and cover it with glycerin and it will not shrink at all. That is because glycerin is so very hygroscopic that it will keep the wood moist. I have some specimens that I treated with glycerin in a showcase at the Laboratory, for an exhibit. I wanted to keep them in their green sizes and shapes. Those specimens have been there now for about 5 years and they have not changed a particle. But I think you can generalize to the extent that the statement is correct that nothing occurs in the ordinary drying of a piece of lumber which affects directly its ability to absorb moisture and to lose it with the constant changes in humidity. If the lumber is heated to 300 or 400 deg. fahr. for about 4 hr., however, its properties will be changed chemically. Its hygroscopicity is thereby reduced very appreciably. In other words, if you subject a piece of dry wood to a high temperature for a long time, it will not subsequently absorb so much moisture as a piece of air-dried wood will, but those are only extreme cases, they are not common ordinary drying cases.

Water-Soluble Contents of Woods

A question asked by L. L. Williams regarding the above subject brings up a matter which, from a technical viewpoint, is complex and a brief answer cannot be given. My reply is likely to be misunderstood. The point to bear in mind is whether we are discussing the subject from the standpoint of a practical drying operation or from that of a theoretical consideration of the chemical nature of wood. Extractions of water-soluble materials and volatile oils are made ordinarily from sawdust or ground-up shavings. The portion of materials removed when wood is dried in the form of boards or planks is extremely small under any circumstances and is not enough to be appreciable in its effect upon the drying or the physical properties of the wood. The sapwood of nearly all species of trees is much more porous than the heartwood, and the soluble materials can be leached out from this part under water; but in many species, as oak, pine, cypress and douglas fir, it is the heartwood which is the important part, the sapwood being narrow and considered a defect. It is doubtful if any appreciable leaching of the heartwood occurs in timbers more than 1 in. in thickness, even when immersed in water for a number of years.

The same statements can be made as to chemical changes that occur in the substances contained in the wood. Nothing ordinarily occurs in the drying or steaming that has any appreciable effect on the properties of the wood, other than a very slight reduction in its hygroscopicity when dried at high temperature. When heated to 300 or 400 deg. fahr. for several hours, however, a decided reduction in hygroscopicity does occur; technically, slight changes occur that are not well understood. Some hydrolization of the hemi-celluloses probably takes place in sapwood with formation of acetic acid and sugar when steamed above 180 deg. fahr., and other changes occur that are indicated by darkening of the color, as in black walnut and red gum sapwoods.

In the case of the pitch pines, 1 or 2 gal. of turpentine and pine oil per 1000 board ft. of 1-in. lumber may pass off in kiln-drying; but to extract these materials completely, the wood must first be ground into small pieces. According to Hawley and Palmer[37], pine blocks larger than 1 x 1 x 1 in. required a steam pressure of 70 lb. per sq. in. to extract as much oil as was extracted from sawdust at atmospheric pressure.

TABLE 1—WATER-SOLUBLE CONTENTS OF VARIOUS WOODS

Species	Proportion of Oven-Dry Sample, Per Cent: Extracted in Cold Water	Extracted in Hot Water
	Sector of Heart and Sapwood	
Longleaf Pine	6.20	7.15
Douglas Fir	3.54	6.50
Western Larch	10.61	12.59
White Spruce	1.12	2.14
Basswood	2.12	4.07
Yellow Birch	2.67	3.97
Sugar Maple	2.65	4.36

	Separate Piece			
	Heart	Sap	Heart	Sap
White Ash	2.24	5.81	3.40	6.41
Yellow Poplar	1.50	1.29	2.08	1.98
Pignut Hickory	2.07	4.91	2.95	6.45
Yellow Birch	4.16	1.05	5.69	1.98
White Oak	7.33	2.55	10.15	4.11
White Oak	4.76	4.27	6.60	5.73
Bald Cypress	2.79	0.72	2.99	1.42
White Pine	5.97	3.55	7.68	5.15
Yellow Cedar	2.88	2.13	4.12	3.41
White Cedar	1.94	2.18	3.22	2.82
Incense Cedar	4.74	1.92	7.08	2.97

Species of wood differ greatly as to the nature of the materials other than ligno-cellulose which they contain. The dye-woods, such as fustic, brazilwood, logwood and osage orange, contain large quantities of water-soluble materials. Chestnut and quebracho contain considerable tannin. Gums, sugars and bitter principles are present in various species. Volatile aromatic oils occur in some species; turpentine and pine oil in the pines and aromatic crystalline compounds in red cedar and African cyp-wood. Western larch sometimes contains as much as 17 per cent of its dry weight of a water-soluble sugar called galactan. Sugar pine contains considerable soluble sugar. In addition to ligno-cellulose, hemi-celluloses, which are more or less hydrolized into soluble substances, are always present in wood. Schorger states that, owing to the highly complex colloidal nature of wood, the results obtained by analysis are not capable of an exact interpretation,[38] and very little is yet known of the chemical nature of many of these substances. Table 1 gives the water-soluble contents of a number of species of wood as extracted from ground shavings or sawdust[39] obtained from different portions of the log.

The volatile oil in longleaf pine varies greatly, from 0.11 to 7.10 per cent of the dry weight. Very little of this oil comes off in kiln-drying.

Subsequent to the presentation of my paper, an inspection of some of the body plants in Detroit enabled me to make some interesting observations. In the first place, very little difficulty with surface checking was seen. It was stated that, prior to the use of certain new and more waterproof priming coats, considerable trouble had been experienced, but that since their recent adoption the difficulty had largely disappeared.

In the last paragraph of my paper I mentioned that the application of a water-stain would tend to produce surface checking. After observing the various processes in body finishing, it seems perfectly evident that it is the application of the large quantities of water when rubbing down the "rough stuff" that has been the cause

[37] See Forest Service Bulletin No. 109.

[38] See *Journal of Industrial and Engineering Chemistry*, June, 1917, p. 557.

[39] See *Journal of Industrial and Engineering Chemistry*, June, 1917, p. 567, and October, 1923, p. 1056.

of the trouble, for the reason explained in my paper. Very few coatings or fillers could be resistant to moisture applied in this way, and the slight swelling of the surface caused thereby would almost inevitably result in subsequent minute surface cracks and "raising of the grain." This latter trouble appeared to be somewhat common even with the new priming coats and is due to the same cause as the checking.

The solution of both troubles lies in the use of a more moisture-resistant priming-coat or elimination of the wetting operation by substituting some liquid other than water which will not swell the wood.

ORGANIZING FOR PLANT MAINTENANCE WORK

BY L. A. BLACKBURN[40]

ABSTRACT

ASSUMING that a system of inspection is more economical and effective than a system for making repairs, the author outlines a plan of organization for a large manufacturing plant. By competent supervision breakdowns and the accompanying unestimable cost of production delays are avoided. In a large plant no one man can be constantly on the lookout for trouble, but a live maintenance engineer can train his organization to watch for unusual developments, and he can hold each department head accountable for the part of the equipment that is allied with his particular trade.

The various departments of such an organization are described in turn and their functions discussed. These include the policing of the plant, protection against fire, maintaining the plant in a sanitary condition, the removal of waste material, the operation of the power-plant and its piping and wiring system, and the inspection and repairing of motors, signaling equipment and metering devices; also such other branches and subjects as the carpenters, the millwrights, the tinsmiths, the machine-repair department, designing and planning, construction work in connection with the repairing and rearrangement of buildings, the storeroom, safety education, first aid, and record-keeping for determining the cost of manufacturing and for the purchasing of supplies.

The organization chart appended is said to have been developed, not with any particular plant in mind, but with the idea that it could be added to or cut down according to the size of the plant or the need of the operation, and that each industrial engineer will work out the details necessary to meet the conditions peculiar to his own company.—[Printed in the November, 1924, issue of THE JOURNAL.]

MAINTENANCE PRACTICE AT THE FORD PLANT

BY E. E. REMINGTON[41]

ABSTRACT

MAINTENANCE is the manufacturer's greatest problem. Being non-productive, its cost should be kept as low as possible. Of great importance in keeping the cost low is standardization of the equipment and of the methods of doing the work. Maintenance can best be accomplished by building-up within the plant a live organization that is equipped to meet all conditions and to give service promptly and efficiently. When the maintenance is adequate, good working conditions follow and good results can then be demanded. The greatest efficiency can be attained when all maintenance and construction work is placed under one head. The organization of the Highland Park plant of the Ford Motor Co. is described, in which maintenance includes millwright work, plumbing, steamfitting, painting, glazing, track work, carpentry, tinsmithing and the fabricating shop; in fact, everything except electrical work and machine repairs.

The factory is divided into five territories, each in charge of a competent man who is responsible for all the work in his territory. Two foremen do not cover the same ground. A floating gang has charge of the heavy piping and of the plumbing, tinsmithing and painting throughout the entire factory. The fabricating shop builds everything from the structural steel framework of a building to a stock-box, for all branches of the Company throughout the United States and foreign countries.

Fire protection is provided by service-men who patrol the plant on bicycles every 6 min. When not on duty as firemen, the members of the fire department are engaged in production work in a room adjoining the fire-station. Cooperation between the maintenance department and the heads of other departments is encouraged and lack of it is not tolerated any more than is any other form of disloyalty or dishonesty.

A large number of special devices to assist in maintenance work have been developed, some of which are described in detail. These include hoists for installing lineshafts, trucks, horses, protective netting for the painters, tool-boxes, tool-racks, cabinets for pipe fittings and a belt-cutting machine.—[Printed in the January, 1925, issue of THE JOURNAL.]

THE DISCUSSION

W. W. NICHOLS[42]:—About 3 years ago I was called upon to assist an automobile plant in making a belt survey. As you all have found out, a large number of machines are overbelted, and some are underbelted. I proposed that they put an Esterline recording-wattmeter on the various classes of machine, to determine the actual power that was being consumed in the various classes of work. They would not do that; they intended to make a belt catalog. I said that I would put the wattmeter on and would go even further. I would reduce the readings to cubic inches of metal removed per minute per watt; and from that data they could determine in the future exactly what sizes of belt would be required by the machines, both on new installations and when replacing the belts of old machines.

Some very interesting results were obtained. One case was in connection with the installation of three new Barber-Colman gear-hobbing machines. We had made a record from an old Gould & Eberhard machine and had found that a very small amount of power was required to perform a certain operation. They wished to perform a similar operation on the Barber-Colman machines. From the Gould & Eberhard diagram, we had determined that a 2-in. belt would drive the machine. Previously, they had always used a 5-in. belt. Anyone familiar with

[40] Plant engineer, Olds Motor Works, Lansing, Mich.
[41] Superintendent of maintenance, Ford Motor Co., Detroit.
[42] A.S.A.E.—Mechanical engineer, D. P. Brown & Co., Detroit.

maintenance work can imagine the "howl" that went up when the machines were belted with 2-in. instead of 5-in. belts. We asked why. They answered that 5-in. belts had always been used. We told them that they had never been needed. Today, those Barber-Colman machines are running with 2-in. belts.

Another thing that can be obtained from the use of an Esterline machine is the best possible check on time-study. It makes a record. Take a punch press, for example. You can get a record of every blank that is punched from the strip, the change in time that is required between strips, the friction load of the machine and the maximum power required.

At the Ford Motor Co., we have been making very interesting tests on grinding crankpins. We have shown the total time that is required, and whether the belts are slipping or pulling as they should. On grinding machines, especially we found in many cases that the tighteners were fluctuating violently because of inequalities in the thickness of the belt. All these things are reflected in the finish of the job. On a Landis grinding machine, you can see the plunger going in and out. On the Norton machine, you can see the tightener swinging back and forth on the countershaft of the belt-driven machines.

An operation like this is very easy in a large shop that is belt-driven. Merely mount a 10-hp. motor on a movable truck-platform, build a deck on the other end of the platform to carry the Esterline meter and put a weight under the deck to help hold the platform steady on the floor. Then throw off the belt from the main line to the countershaft, and belt the motor to the countershaft; you can run in that way as long as you wish. I think you will get some interesting diagrams, especially if they are checked with those of the time-study department.

One other thing that can be used in connection with beltwork is Carl Barth's slide-rule. Many instances occur in the plant in which belt troubles can be overcome readily merely by changing the sizes of the pulleys, keeping the same ratios and increasing the belt speeds. If you will go through your own plants, I think you will find many places where single belts run from the main line to the countershafts and a heavy double belt from the machine to the driving-gears.

CHAIRMAN JOHN YOUNGER[43]:—Maintenance work is too often a matter of expediency. A belt or a pipe breaks, or something like that occurs; when it has been repaired you think the job has been finished, but later on it breaks again and is repaired again and is continually patched. I have seen some plants that have been patched to such a condition that the plant has gradually dropped in value. Instead of making those repairs because of expediency, the question is how heavy should the repairs be to be of permanent value?

ANALYSIS AND MAKING OF REPAIRS

L. A. BLACKBURN:—When a repair is to be made, we first analyze it to determine whether it is an emergency repair or one that will give sufficient time in which to make a study of the application to see whether the breakdown has been caused by misapplication of methods, or whether the machine will have to be rebuilt. We classify as an emergency repair one that is made as quickly as possible and will last until we can get back and make whatever additional changes are necessary.

A new conveyor, when first put into operation, will give considerable trouble. Take, for instance, a sheared pin. That is not a repair; it is more of a replacement. If we find that the pin is too light, we replace it, watch it, and keep a man right there to replace the pins so long as the line is running. As soon as the line is shut down, we see whether the load is too great for the pin or whether the conveyor is of faulty design.

The same method is pursued with belts. An example of this is the case of a machine on which the operation has been changed, for instance, a single-spindle vertical drilling-machine that now has two heads. The machine originally was equipped with a single-ply belt for a single spindle. If the tool designers say they want to put a new head and two drills on this machine, we study the load conditions and watch the belt repairs. Perhaps the belt man will note any unusual trouble quickly, because he will notice that the operator is continually going to the belt crib for repairs. We have the same system that the Ford Motor Co. has; we have a man who looks after the application of belts and keeps up with the demands. All requisitions for belting go through his hands. He determines whether the machine needs a leather, a hog-hide, a canvas belt or whatever is best suited for the job.

We try to keep the conditions uniform and, by requiring one man to sign requisitions for the material, we can regulate the application. He need not be an expert in belting, but he knows more about belting than anybody else in the factory.

We classify repairs. When a motor comes in, we require a written explanation as to why the motor burned out: was it overloaded? was it burnt out from overheating? was it due to the compound used? was it dust from iron filings that got into the coils? or was the belt too tight so that the bearing burned out and let the rotor down on the stator? We have a rule in the factory that a repair shall not be made until the cause of the breakdown has been analyzed. If redesigning is necessary, we do not repair it.

BREAKDOWNS AND THEIR CAUSES

E. E. REMINGTON:—In a case of breakdown, we always get the machine going as quickly as possible, but we begin immediately to overcome the difficulty. It may be be caused by some condition that might never occur again. It is then a case for repair and getting it into service as soon as possible. If, however, we find that the design is faulty, we immediately redesign the machine or reinforce it to prevent the breakdown from recurring.

Many conditions enter into the life and service of a belt that one cannot observe without careful study. We have practically eliminated our belt trouble in some cases on high-speed machines by cutting a belt to a thickness less than that of a light single belt. In other cases, a heavy single belt has given much better service than a light double belt did. We make a practice in the Ford plant of applying with a brush a coat of neatsfoot oil to all of our motor belts; also to the heavy belts used on air compressors and engines. This I think, adds materially to the life of a belt, inasmuch as it keeps the belt soft and pliable so that it never cracks. It gives a surface that clings to the pulley, thereby giving the belt more pulling power than it had before. The application of oil is made about every 4 months.

I am certain that running belts too tight is causing considerable machine repair. We have found out it pays to use a wider belt and to run it more loosely. This eliminates a great amount of spindle trouble on the machine. At the Ford plant, the repairs to a machine

[43] M.S.A.E.—President and editor, *Automotive Abstracts*, Cleveland.

are governed by the production inspector to a great extent. Whenever the stock produced is bad and the trouble is traced to the machine, it is sent to the repair department.

To a great many persons belting is merely belting, but a great difference will be found in belting and in the manner of using it. A belt that will work well in one place may be of little use in another.

We begin a test by putting on the same kind of belt that has always been used on the machine, and run that belt until it gives out. The belt inspector gives it his personal attention. If the lacing breaks or the machine stops for 10 min., he makes a record of it. In other words, he keeps track of the actual number of hours that the belt is in use. When the belt gives out, he replaces it with a belt of another make, and tests it out in the same manner. The record of the tests of two belts can be kept on one card, with an actual account of the production and other data, if you wish to go into the matter thoroughly. All the conditions that surrounded the running of a belt are given on the card. When this has been done, the record is closed and another belt record is put on the other side of the card.

I find that not a day passes in which some company does not wish to send something for us to try out. It is right that we should try them. We must cooperate with the persons that are manufacturing equipment for us or we cannot progress. If they cannot get their material in for trial, they cannot sell it to us. It may be just the thing that we want. If we stick to the old kinds, we may miss that opportunity. So, as far as possible and as far as we think it to be consistent, we try out different equipment, and check it against other equipment that we have been using. The card record is a simple thing. It is easily kept, and when you get through with the test, you know exactly what you have.

Belt-Shifter Forks

Mr. Nichols:—If any one thing more than another in a plant destroys the belts, it is the belt-shifter forks that are furnished with machine-tools in this Country today. I have had American and English planing machines running side by side for 6 years. The English machines did not cause one-half the trouble that the American machines did, all because of the fact that they had roller shifter forks.

We construct a roller shifter in this Country as a rule by putting a piece of gas pipe over a piece of black iron and we expect a man to work around it for 8 hr. a day. He usually puts a nail or a piece of wood in it to stop the noise, making the condition worse than before.

A belt-shifter fork that I have used with good results is shown in Fig. 1. It is made by taking a stud with two reductions; run a ⅜-in. pipe tap-drill the length of the stud, cut a ⅛ or a 3/16-in. slot in the stud for the full length of the roller, put on a washer between the end of the roller and a tie-plate and a nut and a ⅜-in. grease-cup in the end of each stud. If you have a round shifter-rod, merely drill the end opposite the grease cup for it and tap it for a set-screw; or, if you have a plate shifter-bar, make a reduction on the other end of it, thread it and put on the nut. It makes no difference in what angle the fork is hanging, it will always be lubricated. Fill the hole and slot with good Keystone or a stiffer grease.

I have some shifter rollers that are running so fast you must get up on a ladder and put your finger on them to find out whether they are running or standing still. You all have seen shifter forks that are cut half-way through. What causes it? What does it do to the belt?

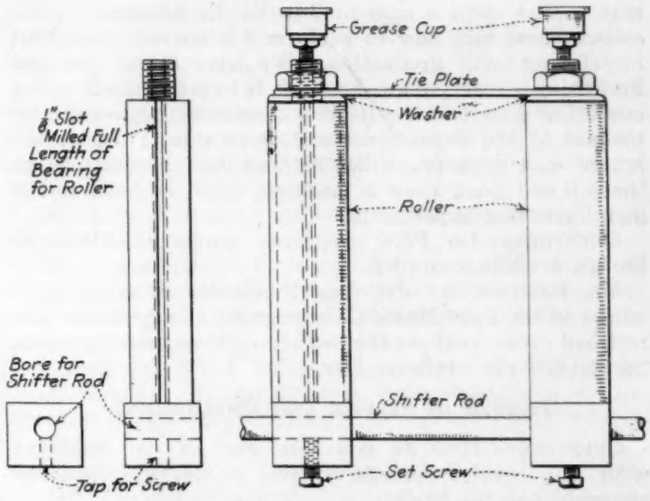

Fig. 1—Roller Belt-Shifter Forks

The Roller Stud Is Machined To Permit the Roller To Turn Freely and the Stud Is Drilled the Entire Length of the Bearing for the Roller. A ⅛ or a 3/16-In. Slot Is Milled the Full Length. The End of the Stud Is Tapped for a Compression Grease-Cup. The Hole and the Slot Are Well Packed with Grease. This Method of Construction Enables the Shifter-Fork To Be Run at Any Angle, and the Roller Is Always Lubricated

It wears the belt in the form of powder, that is, if it is leather, and you don't notice it until you put on a new belt. Then you find that the old belt is about ½ in. narrower than the new one. The edges of a fabric belt get ragged, but this won't happen if a roller shifter-fork is used.

Responsibility for Safety Education

Chairman Younger:—Mr. Blackburn pointed out that safety work, safety instruction and the education of the men at the machines were functions of the plant engineer. My impression is that usually they are functions of the personnel department. Does he not run foul of the production department when he educates men with regard to the use of their machines, or of the personnel department when he takes up questions of safety work that may lead to compensation cases?

Mr. Blackburn:—The principal reason for putting safety work under the maintenance engineer is that the safety engineer should have the proper qualifications. The State law requires that the plant shall be equipped with certain mechanical guards. We have found, however, that the largest percentage of accidents is not caused by lack of safety guards, but by the men's not using their heads in doing the work. To apply safety appliances, a man must of necessity be of a somewhat mechanical bent. He must know how, where and when to guard an operating machine. We do not know what the results as regards accidents would be if the machines were not so well guarded, because we place guards on them as soon as they are installed. When it comes to personnel work, the personnel man is not a mechanical man. He deals with a man with respect to his methods of living, whether he is satisfied and what the plant can do to make him more satisfied. Safety work then gets down to the point of what a man should do. The safety engineer can go to an operator in the machine shop and explain to him, as a mechanic, how he could perform the operation without the hazard that is connected with it. If you try to combine personnel with manufacturing, therefore, confusion might arise.

We classify it separately, because of the nature of the work in which the man is being instructed. A personnel

man cannot show a man how to handle machinery. He cannot show him how to perform his operation without interfering with production. We have found that the first thing a safety man should do is to sell himself to the operating department. He must begin with the superintendent of the department and work down; not at the bottom and work up. Once he does that, he must be on the job and must know a machine, when he talks to the manufacturing department.

QUESTION:—Do Ford employes smoke anywhere in the plant while on duty?

MR. REMINGTON:—No man is allowed to smoke anywhere on the Ford Motor Co.'s property at any time. The railroad crews that do the switching stop smoking when they reach the property line.

LENGTH OF SERVICE AND EMPLOYMENT

QUESTION:—How do you take care of old employes with long service records, if you do not use them as sweepers and the like?

MR. BLACKBURN:—That is a pretty hard question to answer, and it is much more so when you say that you do not take care of them. We do! We make them elevator operators in some cases, and in other cases place them at the gates. They also assist in the sorting of scrap. You can show a man that a piece of brass goes into one bin, steel into another and cast iron into a third. In that way, we have been able to take care of old pensioners to whom we have felt obligated. There is always some job about the plant that an old man can do, but sweeping is not an old man's job, if you expect to keep the plant clean.

QUESTION:—Have the sweepers ever been put on a bonus basis?

MR. BLACKBURN:—We have never tried it. I should like to know how it could be done. I should like to know if there is an average area that one sweeper would take care of. If we could decide on an area that a man could take care of and if the man were to say that he could take care of 1000 more sq. ft., he could be placed on a bonus basis. You must take into consideration the different departments, such as those in which the sweepers have to cart out many hundreds of pounds of cast-iron shavings. You can, of course, purchase additional equipment that has been developed and can cut down the force with it. When additional equipment is supplied the sweepers take the shavings to the aisle; from the aisle the carts are collected by tractors and are taken to the scrap pit and dumped. The men, therefore, have only to take the shavings to the aisle.

If some specific area that a man can take care of could be determined upon as being worth 40 or 50 cents per hr., say 10,000 sq. ft., and if he were to take care of 1000 sq. ft. more, we could say that we would give him a 10-per cent bonus.

A MEMBER:—Our plant is not very large but sweeping has been a problem. We found that we were spending a certain amount of money for it; the turnover among the sweepers was large and we were not satisfied. I checked up for a certain period to see what it cost. I went to our equipment manager, in charge of that division, and said to him: "Offer the same amount, the average cost that we pay those men and tell them that if they will work in a group and keep the plant clean while eliminating one or two men, the saving in wages will be 'gravy' for them."

It is surprising how it worked out. It had been going on for only a few days when one of the men came to the boss and said, "I do not want that man on our job. He is not working." The boss answered, "Can you get along without him?" "Just give us a chance," the man replied. On some days on a certain floor not much cleaning was required, so this man was anxious to help out the other men. The first thing we found out was that in the assembly departments the cost of sweeping had decreased. The men were only too anxious to get into the machine shop and help clean up. As a result the turnover of sweepers decreased. We have a cleaner plant at a lower cost. I am certain, therefore, that the plan can be worked in almost any plant. We are very well satisfied with the results.

CHAIRMAN YOUNGER:—How do you take care of the cleaning up of old crates and the like?

A MEMBER:—We have a space in which to burn crates in the yard at our own plant. It occurred to me when I came to a little shed in which we store lumber for crates for service parts, that we might be able to make use of those crates. I had seen them burning perfectly good crates many times before and, at the same time, was buying lumber to make service crates. After determining the lengths of lumber required, I found that it was very easy to build a little shanty containing a motor and a saw and to cut up the lumber of the crates. We figure that we are saving about $10 a day. It requires only one man to take care of that operation. An appreciable sum of money is saved in that particular job. Not only that, but the plant is kept clean and in better shape.

MAINTENANCE AND PERIODIC OVERHAUL

MR. NICHOLS:—I have often noticed that the belts on motor drives are put on as tight as a fiddle string. The consequence is that the bearings become hot just as they do on the countershafts, on the pulleys of clutch pulleys and on loose pulleys on the countershafts, all because of the excessive tension at which the belts are run. A heavier weight of belt or an increase in the width of face of the pulley would eliminate much of the repair work necessary to the motors.

Keeping down the costs in the maintenance department is a thing that the maintenance man must fight the hardest, to find out where the money is being expended. As a rule, just one account in the shop is for maintenance. When in doubt as to what to charge time, it goes to maintenance; and when the money has been spent and the maintenance cost has run up, a dispute follows because the accounting department cannot sub-divide the accounts so that the maintenance man can put his fingers on them and show exactly where the money has gone.

CHAIRMAN YOUNGER:—One question always arising in maintenance considerations is that of periodic overhauls. Should the machines be taken out of the line periodically and given an overhauling regularly before the breakdown? Should they have constant inspection and wait until they are almost at the breakdown point? Why not have lubrication, machine adjustments and the tightening, renewal and dressing of belts performed periodically in accordance with card ticklers in the machine-repair and millwright departments?

MR. BLACKBURN:—To have a tickler file for every machine in the plant would be too cumbersome. It would require as many men to keep track of the tickler as to perform the work. As the production varies, the use of the machinery varies. Therefore, if an area man is constantly on the alert, taking care of his machinery, it should not be necessary to tell him that it is time to oil the machine. We are great believers in area men; that is, men who are in a definite area. They work all the time and are responsible for that area. If a bearing breaks-down because of lack of oil, the area man that is

oiling is responsible not the machine operator. It is not the machine operator's fault if the oiler does not take care of the machine.

As the production varies, the requirements for oil certainly vary; as the production goes up and down, the requirements also go up and down. Very few corporations have a steady production. If production were steady, that could be done, provided the machines were all built by the same manufacturer, the oiling were the same, the kind of oil used were the same, and the time that the machines would run on that oil were the same. If you were to try to pick out one machine in this bay that needs oiling today, and another machine in another bay that needs oiling tomorrow, in the meantime you might overlook some machines that have entirely different lubrication, some with force-feed and requiring only that the reservoir be kept full, others with oil-cups and so on. The only system, therefore, that could be used successfully without being a burden is one having the proper kind of supervision in the area, with a man who does not have more than he can take care of, and the kind of man at the head that will see that he keeps up with his work.

Motor Inspection

QUESTION:—When is the motor inspection done, regarding hot bearings, oil and dirt? Do area men change the motors?

MR. BLACKBURN:—In the part of the industry with which I was connected during the war, we had probably the most difficult problem that has ever confronted the electrical industry. As a matter of fact, the largest companies in the business simply threw up their hands. In a nitrating house, the life of a motor on a dipping tank ranged from 24 hr. to 1 week; if we got a week's run we were lucky. That meant that production was so hampered by the cutting down of the dipper line that it decreased from possibly 100 to perhaps 80 per cent.

As the manufacturers were busy on other things, making machinery and not maintaining it, we developed a system of "doping" the motors, that is, covering the coils entirely, a system that has recently been adopted by one of the largest electrical machinery companies; you can get a motor from them compounded originally today. We found, however, that even that was not the answer.

Sundays, we ran three shifts; the men that worked the Sunday previous were off, but the next crew came on; and it was their duty to tear-down certain motors, that is, take the rotor out, clean the stator and the bearings and change the oil. Motors that originally operated for 24 hr. operated for 3 years without a burn-out.

That system applies to the automobile industry, especially in the motor plant. It means that, periodically, when the plant is not operating, if you have individual drives, you can get certain machines each day, take the end bells off and the rotors out, clean them, give them a coat of paint and inspect the bearings and put them back; and they will run indefinitely. They must be inspected and tested for clearance by the area men. In other words, the statement that an electrician and helper can take care of 300 motors in a motor plant means that they tear-down the motors, watch them and as the accumulation gets on the stator, the end bell and the rotor are taken out, given a coat of paint and put back into operation, and the bearings are inspected. How often the operation must be performed depends entirely upon the production.

Other Routine Details

QUESTION:—Who takes care of oiling the machines, the operators or special oilers?

MR. BLACKBURN:—Special oilers.

QUESTION:—Are area stockrooms in charge of stockkeepers?

MR. BLACKBURN:—It depends entirely upon the size of the stockroom. Ordinarily, it is not necessary to have a stockkeeper in an area stockroom. Usually the shop foreman in the area can take care of the stockroom and keep up his stock and his records.

QUESTION:—Is a record kept of the idle time of machines?

MR. BLACKBURN:—It is not kept in our plant but it should be, especially when we are up to production. That removes the alibi between the production and the maintenance departments.

QUESTION:—What method is used to control maintenance costs? Is maintenance work charged to the individual department or charged to a general maintenance budget?

MR. BLACKBURN:—In our department we have a timekeeper who distributes all the time of the different departments. For instance, in our accounting system we have a building-account number. All repairs to buildings are charged to that number and to the department that is in the building. All repairs to machinery and motors go into a like account that has its number with the department that receives the work. That system reminds the operating men that if they "lambaste" a machine as hard as they can and care nothing for production, they must stand the cost of the damage; and when that gets beyond a reasonable limit, it is the duty of the manufacturing department to inform the department of its abuse of the equipment.

Motor Protection

QUESTION:—What special protection is used to protect motors from cast-iron dust in the cast-iron department?

MR. BLACKBURN:—The General Electric Co. uses a compound, an analysis of which I do not have; we are using the same compound that we developed during the war. We began with ordinary road asphalt, which has a melting-point higher than that of tar. It is pliable and keeps the cast-iron dust from penetrating, but will not run. We had trouble with the compounds running in motors that were somewhat overloaded; we continued to experiment, were in touch with different refining companies and finally secured a compound from the U. S. Asphalt Refining Co., of Baltimore; it manufactures a compound called No. 300 Rubrax. I have never had this analyzed because, so long as it met requirements, we were not interested in the specification. It has a higher melting-point than any other we have ever tried. It is easily applied and will not run under reasonable conditions, that is, if the compound is properly applied, even though the motor is overloaded.

It also has a coefficient of radiation that the General Electric Co. maintains is not so high as that of the compound which it uses. The compound that we use, however, is so much more easily applied and the coils are so much more easily cut, in case the winding of the motor is defective, that we have stuck to it in preference to the General Electric Co. compound. We find that, so far as the heat radiation is concerned, it is equally efficient.

The stator is put into the oven, heated, brought out and dipped just up to the laminations. A certain quantity of the compound will stick. With the blow-torch and a putty knife, it is smoothed over. In other words, just as thin a layer of the material is put on as is necessary to protect it from the iron dust. But the coil must be cleaned; because, if the iron dust accumulates and the rotor rubs, trouble will ensue.

Responsibility for "Layout"

QUESTION:—Should "layout" come under production or standards or plant engineering?

MR. BLACKBURN:—That is a subject about which everyone probably has his own opinion. The efficiency of a maintenance engineer depends upon his knowledge of operations. If he does not understand the operations, how can he apply a remedy for the "grief" that the operating department is having? The building layout should come under the plant engineer or the maintenance engineer. He designs the building that will take care of a specified load. If he is not familiar with the layout of the machinery that will be installed in it, he must take someone else's word for it. If he falls short, he says, "Well, Bill told me that the machinery that was going into that building would have so much load per square foot." But if he is familiar with the operations, the heat and ventilation required, the piping and the power that will be necessary and all the commodities that come into that department, he will be able to do much better work. If a maintenance engineer has a good idea of all the operations that are being performed in his plant, he has a better idea of the most efficient type of building that can be designed for them and the most efficient layout for the commodities; and every department needs practically all the utilities, namely, steam, air, water, gas and electricity.

JOHN MCGEORGE*:—In that connection, the time-setters of the production department, if they are of any use, should claim the right to determine the sequence of operations but, on the other hand, according to your idea, if the plant engineer is to decide upon the sequence and the method of operations, will not the maintenance department and the production engineers clash?

MR. BLACKBURN:—When the maintenance department begins a layout, it lays out the machines that the manufacturing department has specified for certain operations. The sequence of operations is laid out from a routing-sheet. In other words, say, a machine is purchased to perform operation No. 9990. It comes, we will say, just after the roughing of the flywheel. The maintenance department lays out the machines in the most economical manner of operation from one to another, with all the necessary intermediate means of handling the equipment. In other words, the manufacturing department sometimes specifies a machine, but does not specify how the work passes from one operation to the next; by truck, by gravity conveyor or by hand.

In any department or any operation you can find a chance for a clash; but why not make it easier and have the departments tied-in so that the manufacturing department will work with the maintenance department just as the engine department works with the assembly line in building an engine to fit the chassis that the engineers have designed? It is not a question of putting the entire responsibility on one department, but of placing the whole operation under a department that will have the supervision of it.

CHAIRMAN YOUNGER:—Would it not be more logical to have the safety man instruct the foreman of the department and have the foreman instruct the men? Would that not obviate the clash?

MR. BLACKBURN:—I believe I said that the safety engineer's work should start with the superintendent of the department and go down, not from the operator and go up.

A MEMBER:—We have learned from Mr. Remington that the Ford Company moves over 9000 machines a year. It is impossible to lay down fixed rules regarding maintenance and how certain factories must be built. These transformations are found in most plants today. The same is true with the safety man. Since the earlier days, the Ford Company more than any other organization, has always kept the safety engineers separate. Even today the same rule applies, that they are responsible to the general manager only. They work in very close touch with everyone but they train their own force. Of course, they use high-grade mechanics, specially gifted men. But to lay down a rule that the maintenance department shall have the final say regarding the sequence of operations is not possible. Even today in the largest shops the sequence of operations may be changed three times within 48 hr. Machines are being equipped more and more with efficient motors that cause very little work for the maintenance department.

I think that, after all, it is the production engineering department of any plant, large or small, that should finally determine all the ideas that we have heard about in the last ½ hr. The closest cooperation is necessary and, by putting little pamphlets into the envelopes of employes, a spirit can be created before long that will cause the men to pull together.

Power and Other Costs

QUESTION:—What is the approximate amount of steam generated and the cost per 1000 lb.; the approximate amount of electricity generated and its cost per kilowatt-hour; the approximate amount of air generated and its cost per 1000 lb.?

MR. BLACKBURN:—We purchase all our power. It varies entirely with the production. The consumption of electricity per month varies from 1,000,000 kw-hr. down. The demand varies from 3000 kw. down. The air-consumption varies from 2,500,000 cu. ft. per day down. The steam generation varies entirely with the weather, and is from 1,000,000 lb. per day down. Our steam load is principally for heating. In summer the production is about 700 boiler hp. In buying electricity, which we purchase from the City of Lansing, we are penalized for power-factor, which varies with the demand from 98.5 per cent for the minimum to 82.0 per cent for the maximum demand. We receive a bonus when we are above 80 per cent and are penalized when we are below 80 per cent. We reach a good power-factor by the use of static condensers. The cost varies from 1.25 to 1.80 cents per kw-hr.

The total steam cost, including overhead expenses and fuel, is about 55 cents per 1000 lb. of steam as an average for the year. The low cost is 40 cents per 1000 lb. for January and February. The cost of air is about 7 cents per 1000 lb., and includes overhead expense, fixed charges and the like.

I should like to correct one impression that seems to have been made. It is not my idea that the maintenance department should tell the operating department when an operation is to come in. The layout department merely takes the routing sheets that are made by the manufacturing department from the engineering-department specifications. It applies only the information that is given to it on the routing-sheet. It does not attempt to run the plant, or to run the production department. It lays out the work and the sequence of operations in the most economical way. After the machinery has been installed, if we find in the layout that an operation can be done better on one side of a machine than on the other, it will be laid out that way. The manufacturing

* M.S.A.E.—Consulting engineer, works engineering and maintenance departments, Oakland Motor Co., Pontiac, Mich.

department always has the privilege of saying that it wants it a certain way and, if you cannot convince it that you are right, the machines will go in that way.

Safety Engineering

MR. REMINGTON:—With regard to safety work, one thing which we have found out is that if the safety engineer is to accomplish anything he must have practically everybody in the plant back of him. For instance, if he goes into a department and finds something wrong in the line of production, unless he has the authority to stop that operation immediately, or to make arrangements to have it taken care of, it will drift along; and if anything ought not to drift along, it is lack of safety equipment.

At our plant, the safety department is very close to the superintendents, and the superintendents are behind the safety engineer to a man. If he says that something looks feasible and ought to be done, it is done and nobody can stop him. He can stop any number of machines. It is our task then to get them going, because we make the guards. The safety department sometimes furnishes us with the drawings and the sketches for the guards. At other times, if it is rushed we send out men to design the protection. All the guards, however, that we sketch are sent to the safety engineer for his approval. If we are installing equipment of any kind, their man is always present; if we overlook some safety methods, he calls our attention to it and we take care of it.

So far as the safety man's consulting the head of the department is concerned, when a man is doing an operation he gets the man right at the spot and gets the foreman afterward. Any man who is found to be doing an absolutely careless thing is taken off the work immediately and spends from 1 hr. to 2 days in the safety office looking at safety pictures. By the time he has finished, the first thing he thinks about is safety. That seems rather hard. No one likes to take a man away from his work and make him lose time, but sometimes the only way we can reach a certain class of men is through the pocket. We find that it has worked out very well. Many of these men plead to go home; they would like to go home and do something while they are off pay; but their job is to stay there looking at safety pictures; and they do not have a chair to sit on, either. The pictures are mounted on the wall. It is the absolute duty of every manager and of every department foreman to back up the safety man to the last degree.

Development of Men

Some methods of the Ford plant are not carried out so strictly in other plants. Our maintenance department comprises something more than maintaining the plant. No department of any organization ought to turn out so good an all-round man as does the maintenance department, because the work is so varied. A man who stays in the maintenance department for any length of time ought to know how things should be done and that is the kind of man we are looking for.

We take care of considerable work through our department for points outside the plant. At present, I have men at the Charlotte, Jacksonville, Dallas and Twin City branches, installing machinery that we build in Detroit. It takes a man with brains to handle that kind of work, because he goes to a place in the same way that a contractor goes. I bid for work at the branches against outside contractors. If I am lower than they are I get the work; if I am higher, I lose it.

We are not only developing men, but are discovering new men. For instance, the man at the Twin City branch is building a powerhouse and installing the boilers. He was an assistant foreman in the construction department, a good all-round Scotchman. Before I sent him down there, he took care of the outside work in the city, at the Ford hospital, the Lincoln plant and some at the Dearborn plant. When he was sent out, the man below him in the plant was promoted to his place.

At the time I sent this assistant out, the head foreman in the construction department in Detroit said, "That hits me pretty hard." I said, "That's all right. The man below has to learn and he might as well learn now. You will find out in that way what you have below in the way of material." As soon as I sent the man to the Twin City branch, I sent the head of the department out into the city and let the next man become head of the department. So, we are continually finding out what material we have below.

QUESTION:—Are machine-tool builders asked to produce machines according to the safety specifications or the safety code of the States to which the machines are sent? For instance, in Michigan, do you ask machine-tool builders to furnish machines in accordance with the safety code?

MR. BLACKBURN:—I think that question has never been brought up. It has never occurred to me to require them to build machines according to that code. The idea is to build a machine that will produce; we apply the safety appliances after it has been installed.

MR. REMINGTON:—I would not be quoted as saying so positively, but I think that we buy no machines until they have been properly guarded.

QUESTION:—What is the percentage of the men in the maintenance department to the whole number of men in the plant?

MR. BLACKBURN:—At present, little construction work is in progress; we have a maintenance department of about 165 men out of a working force of a little more than 2000.

QUESTION:—Who estimates the machine load, and who is responsible for the purchase of new equipment?

MR. BLACKBURN:—We have a department known as the manufacturing-engineering department. It gets the drawings of the parts from the engineering department, and decides on the type of machine on which that particular piece can be machined most efficiently. Several different kinds of machine may be able to perform the same operation. The manufacturers who are asked to bid on the machines submit an estimate of the number of pieces that their machines can turn out per hour in accordance with the engineering-department drawings.

Observations of a Superintendent of Motor-Truck Fleet-Operation

By J. F. WINCHESTER[1] METROPOLITAN SECTION PAPER

THE following written discussion of Mr. Winchester's paper on the subject of motor-truck fleet-operation, which was printed in THE JOURNAL for May, 1924, was received subsequent to publication of the extended discussion in the issue of THE JOURNAL for December, 1924. In the present discussion Mr. Pettit refers to remarks by G. R. Gwynne[2] regarding the maintenance of a fleet of vehicles operating in the States of Montana, Idaho, Utah, Wyoming, Colorado and New Mexico, with repair base-stations at Salt Creek, Wyo., 42 miles from the nearest rail-head, and at Butte, Mont., 400 miles from the nearest parts depot located in Salt Lake City. The following abstract of Mr. Winchester's paper is reprinted for the information of those who did not hear or read the paper and to refresh the memory of those who did as to the ground covered by it.

ABSTRACT

SOLICITATION of sales and the delivery of the product to the customer constitute the most important operative features of the motor-truck fleet supervised by the author. Endeavor is made to install the vehicles in the various fields along standardized lines. The volume and the extent of the business and the topographical conditions of each locality determine the size and the mechanical equipment of the vehicle that is employed, and it is installed only after a study of all the conditions pertaining to its operation.

Adequate training of vehicle operators, not only along mechanical lines but also as direct sales representatives of the company, is made a feature; and so is accident prevention. These interests are prompted in various standard ways and are furthered by the publication of "house organs." After a vehicle is installed the slogan adopted is: Keep It Moving With a Pay Load.

Methods of mechanical upkeep are outlined, special tools and fixtures used are illustrated and valuable details of maintenance practice are stated. Engineering factors that affect fleet operation are discussed, as well as details relating to tire selection. A magazine system of chassis lubrication is advocated. Brakes, wheels and accessories are treated from the standpoint of design, simplicity and accessibility being the keynote. Operating costs, records and record forms are considered in general and, since adequate records are a necessity if fleet operation is to be successful, some specific recommendations are made concerning them.

THE DISCUSSION

HAYES D. PETTIT[3]:—I would like to know how Mr. Gwynne operates overhaul stations so far from a repair-parts base, as I find our equipment tied up almost daily for lack of parts although the inventory of parts in our central repair-shop amounts to $380,000.

We have operated on the unit-repair plan for some time, shipping out complete units to replace broken units, and at present we are converting our central repair-shop from the old system of overhauling equipment after it arrives in the shop to a unit-repair system that includes the dismantling of each truck on its arrival and installing new units throughout, such as a rebuilt radiator, engine, clutch, transmission, universal-joint, front and rear axles, steering-gear, lighting equipment and accessories.

One major complication is that among several hundred passenger cars we have no less than a dozen makes and many models to contend with, and among nearly 1000 trucks we have 23 makes and from 1 to 173 trucks of each make, and several models of some makes. Moreover, the body equipment varies from a motorbus or personnel body to road-oil distributing tanks. The repair-shop operation is further complicated by the fact that we must maintain and service air compressors, gasoline engines, road rollers of steam and gasoline power, cranes with both steam and gasoline powerplants, motorcycles, snowplows, derricks, steam and compressed-air drills, trailers, steam and gasoline locomotives, concrete mixers, cement guns, traction engines, steam shovels, road-oiling equipment, chip spreaders and every type of road-making machine.

OPERATING ON A FIXED-RENTAL SYSTEM

One system that we started in January, 1924, and that is not in use by other fleet owners, I believe, may be of interest to fleet-operating Society members. It is a system of rental charges based on the cost data of former years. The objects of this rental system are to (*a*) fix charges that will cover depreciation, repairs, operating costs and drivers, and still show a profit to provide a sinking fund sufficient to purchase new equipment to replace the worn-out equipment, (*b*) avoid the necessity of charging breakdowns, repairs and worn-out equipment to any individual job, and (*c*) make the repair-shop self-sustaining so that no appropriations are required for it.

Regardless of what job the equipment is being used on, a fixed daily or hourly charge can be made against the operation or job. The old way was to send a truck to a job and charge for the gasoline, oil and repairs. If the truck was a new one the job would show a low cost, whereas, if an old truck in only fair condition and that perhaps cost much more to operate and keep in repair was assigned to another job, that job would show a higher cost. For that reason, under the rental plan, every job is charged a certain price per hour for each type of equipment, regardless of whether it is old and costly or is in good condition and runs at a low cost. The central repair-shop is charged with all repairs, parts, labor, drivers' wages and upkeep and receives credit for the rental of all equipment in use, so no appropriations are required, as it is self-sustaining.

Our first year's trial of the rental plan has been so satisfactory that we will have earned from the rental charges nearly $1,000,000 surplus with which to purchase new equipment to replace all equipment that is old and

[1] M.S.A.E.—Supervisor of motor equipment, Standard Oil Co. of New Jersey, Baltimore.

[2] A.S.A.E.—Chief automotive engineer, Continental Oil Co., Denver. See THE JOURNAL, December, 1924, p. 572.

[3] Department of Highways, Commonwealth of Pennsylvania, Harrisburg, Pa.

costly to repair. This may cause the assumption that the rates must be high. To dispel that idea a few of the rates fixed for the first year, and which will require very little change this year, are given in Table 1. In most cases the rates are less than those at which we can rent similar equipment from private sources.

TABLE 1—RENTAL RATES FOR 1924, INCLUDING OPERATOR, FUEL AND OIL

Type of Equipment	Hourly Rental
Buick Touring Car	$1.30[a]
Cadillac Sedan	2.08
Cadillac Touring Car	1.85
Dodge Touring Car	1.26[a]
Hudson Roadster	1.56
Reo Touring Car	1.45
Studebaker Touring Car	1.55
1-Ton Motor Truck	1.38[a]
2-Ton Motor Truck	1.73[a]
3-Ton Motor Truck	2.02[a]
5-Ton Motor Truck	2.32[a]
5-Ton Tractor	2.11
10-Ton Tractor	2.83
Motorcycle, without Operator	0.16
Motorcycle and Side Car, without Operator	0.17
Steam Cranes (under 15 tons)	1.94
Steam Cranes (over 15 tons)	2.36
Cement Gun	4.84

[a] Average for several models.

From these prices it can be seen that the rates are not excessive. The plan offers the central repair-shop an incentive to repair well and quickly, as every day that a piece of equipment is laid up the shop receives no rental income from it. An inducement is also afforded to make repairs at the lowest cost, as the money expended for equipment upkeep reduces the surplus and it is human nature for mechanics to want new equipment to work on. All equipment overhauled in the central shop is rebuilt like new equipment, with the closest possible fit of parts, and the best workmanship possible keep the equipment in the best operating condition and brings in the largest rental returns.

I should think this plan could be used by any corporation; for example, a gasoline company could charge each day's rental to a known gallonage delivered. Our equipment is distributed throughout Pennsylvania and the rental records are kept at the central repair-shop from monthly reports submitted by the field superintendents, which, in the case of the gasoline company or any other fleet owner with wide distribution, would be the branch managers, sales managers or other supervisors.

Unit Plan of Overhauling

We are now making ready to take up the unit plan of overhauling. This resulted from the adoption of the rental system, as under that we lost the rental of a truck brought in for overhauling that usually required from 4 to 6 weeks to overhaul, test and paint. It is expected that under the unit plan a truck can be dismantled, rebuilt with rebuilt units, tested and painted all within a week, so we hope to add considerably to our income in 1925. We are now at work rebuilding extra engines, transmissions and other units.

The point raised in Mr. Winchester's paper about engine-number records presents no difficulty as all State highway departments permit as many engine changes as desired. No charge is made in Pennsylvania for changing engine records on licenses, and we keep card records of all of our equipment, with serial and engine numbers, and as each change is made the record is corrected. The only trouble we anticipate with this record system will be caused by our dynamometer records, which are kept by equipment number and not by engine serial number, so that the test report may be incorrect for a few months but this presents no serious problem.

Papers of the kind presented by Mr. Winchester are of especial interest to us who must service large fleets of trucks and I am sure they will be of some help to the factory engineers, as service-men often show the engineers causes of troubles that should and can be corrected. Many such cases have passed through my hands that have resulted in the factory making improvements after troubles developed.

Requires 24-Hr. Service on Parts

G. R. Gwynne:—The answer to the first question in Mr. Pettit's discussion is indicated by him in his third paragraph, in which he states that among several hundred passenger cars he has no less than a dozen makes and models, and among 1000 trucks he has 23 makes. We operate a standardized fleet of motor equipment which is distributed widely. While we have a number of different makes, the vehicles are all standard models. For the last 10 years we have been purchasing our motor-truck and passenger-car equipment with the idea that, although a job may be of the highest type of engineering and of the very best quality from the standpoint of workmanship and material, it is worthless to us as a means of transportation unless the manufacturer is in position to render service, and by that we mean the distribution of parts.

It was not possible to carry out this policy during the war period, when we had no alternative but to buy whatever equipment we could secure, but most of that equipment has now been retired into what we call our "obsolete class." This includes all orphaned units and those units that have been made obsolete by radical changes in design by the manufacturer. This obsolete and orphaned equipment is retired from active field-service and is operated in the cities, or within a radius of 5, 10 or 15 miles of the cities where we operate our base shops and where we can secure parts either from a factory branch or from responsible distributors.

As to securing parts generally throughout the 13 states in which we operate, we are operating and purchasing only that equipment on which the manufacturer can guarantee, at the most, 24-hr. service on parts. The number of manufacturers of high-type trucks and passenger cars on the market that have factory branches or responsible distributors who can render this service is remarkable.

Rolling Stock Preferable to Parts Stock

Referring again to the first paragraph of Mr. Pettit's discussion, he states that the inventory of parts in his central repair depot amounts to $380,000. Assuming that figure to be the actual inventory and an average value of $3,000 per unit of mobile equipment, it represents a capital investment of 123 complate structures: I do not believe Mr. Pettit can rebuild more than that number of jobs in his base shop at one time. Therefore, if the $380,000 had been invested in surplus rolling stock, I believe he could operate more easily without stocking parts. Certainly, from the standpoint of overhead, 123 trucks and passenger cars are much more easily accounted for, with less overhead, than are $380,000 worth of parts. This is a simple problem that, in engineering, resolves itself into the old fundamental principle of "disposition of material," as it is called in production; and wherein is the difference between dollars and material? If Mr. Pettit would analyze the situation thoroughly along these lines, from an

engineering standpoint as well as from a business standpoint, I believe he would agree that $380,000 could have been invested so as to secure much better transportation service.

We have 6 base shops, with a total of 47 bays, or an average of 8 bays per shop. Each base shop is the headquarters of a motor equipment division, and each division is motorized on a scientific basis to give the greatest volume of work per unit that can be accomplished. The equipment is known as "authorized" or permanent equipment. Then we have a surplus of equipment, known as "active relief," of various makes and description, a total of 21 units, which are distributed in threes and fours among the 6 base shops. These units are used for the permanent replacement of units of like nature in the field, which are brought to the base shop for rebuilding. This allows a certain period, say 7 to 10 days, for securing new parts for rebuilding.

Rental Plan Should Include Overhead

In Table 1 Mr. Pettit shows operating cost per hour. Does this cost include the overhead of housing his $380,000 worth of parts, clerical help necessary to keep account of the parts, 10 per cent depreciation on parts in the bins, and 6 per cent for the money invested in these parts; and does it include heat, light and power for the shop, dead time of shop force, supervision, replacement-tool expense, garage-shop-supplies expense, executive expense and the myriad expenses that go to make up overhead cost? We find that overhead is a considerable item in the maintenance of truck fleet. Or, is this rental per hour based only on direct expense?

Our work is as complicated as that of the Pennsylvania Department of Highways, as we take care of drilling engines, oil-field electric powerplants, Moon generators, the manufacture of drilling nipples, the re-formation of 20-in. drilling bits, Holt Caterpillar tractors, stationary 50-hp. gas-drilling engines, rotary pumps, shipping pumps and so forth. The rental-per-hour plan would be impracticable for our company because we have peculiar marketing conditions and a marketing corporation must know its cost at each individual station. Therefore, we compile sales figures and calculate the cost per gallon of gasoline delivered at every station in the 13 States in which we operate on a standard motorized basis.

Asks Mr. Gwynne for Data

Mr. Winchester:—I feel that the point raised by Mr. Pettit about Mr. Gwynne's operation is well taken. It is evident that the comparative ease with which Mr. Gwynne handles his overhauling stations so far from a repair-parts base does not work out well with Mr. Pettit. My experience has been exactly the same, operating many pieces of equipment of makes and capacities similar to those operated by Mr. Gwynne.

It would be interesting to have Mr. Gwynne outline accurately the following:

(1) Number of days his equipment operates per year

(2) Number of hours the equipment operates per day

(3) Proportion of time which the operator charges to direct operation and to repairs

(4) Number of pieces of equipment on which a helper is used

(5) Percentage of time lost because of central supply-station vendors not having the material on hand, or supplying incorrect material which may originally be their fault through incorrect measurements or through their having supplied incorrect parts-catalogs for the ordering of replacement material

(6) Comparison per miles per gallon of new equipment with old equipment that has run the high mileage quoted by Mr. Gwynne

These are questions that have come to my mind and have been expressed to me by others who have read the discussion on this subject. Certainly we in the East can learn much from Mr. Gwynne about economical truck operation, based on some of the statements made regarding his operation under the severe conditions he encounters. A complete discourse on this subject by Mr. Gwynne would be of value to us all.

The plan of operation described by Mr. Pettit is interesting. A committee of transportation engineers, of which I am a member, is studying the operation of motor equipment in the City of Baltimore at present, and a similar plan has been suggested by one of the engineers who is a member of this committee.

I am certain that the information given by Mr. Pettit will be of great value in the deliberations of this committee, which has primarily in mind the coordination of the various motor-vehicle departments in Baltimore, with the object of reducing the cost of operation and maintenance, which ultimately will be reflected in lower tax rates to the citizen.

Days and Hours in Service

Mr. Gwynne:—The total figures covering the number of days equipment operates per year (1) for our entire fleet for 1924 are given in Table 2.

TABLE 2—DATA ON TIME PER YEAR MOTOR-TRUCK EQUIPMENT IS IN SERVICE

	Per Cent
In Service	69
Out of Service on Sundays and Holidays	14
Available for Service but Not Used[4]	7
Out of Service for Repairs[5]	10

[4] Includes surplus or "active relief" equipment, as previously defined.

[5] Includes vehicles laid up because of accidents and for rebuilding and those in use for field inspection, field service and driving to and from base shop.

The information presented in Table 2 includes all classes of equipment, from the small passenger-coupé used in sales service to 5-ton dump trucks used in 24-hr. service on coal hauls to the refineries.

The number of hours the equipment operates per day (2) varies in different localities. We do not compile annual average hours per day, as each truck is analyzed each month on its hours of production. These hours are recapitulated on the monthly reports coming to the home-office automotive department from the operating divisions. We accept a 234-hr. month as 100 per cent, based on 9 hr. per day, 26 days per month, and we expect a flat average from each unit of 212 hr. per month, allowing 22 hr. per month for loading in the warehouse. Operating time is checked from the time the truck leaves the warehouse until it returns but no explanation is required for lapse of time in the warehouse.

All drivers' time is charged to truck-driver cost. His duties are to drive his truck intelligently and to grease and clean the unit every day. We do not permit our truck or passenger-car operators to make repairs, as this would mean ruination of the structure; no operator is allowed to make any kind of repair other than emergency repairs that may be necessary on the road to enable him to get back to town. The mechanical departments, known as base shops and placed in charge of garage-shop superintendents, effect all repairs and are held responsible for any failures should they occur, but

we do not have failures. Only in emergencies, such as accidents, do we allow any work to be done by outside garages. All repairs are effected through the medium of traveling inspectors or service-men, who travel out of the base-shop headquarters.

We have no helpers. All loads are waiting for our trucks upon entry into the warehouse plants. It is part of the warehouseman's duty to assist in loading, and this work is charged to warehouse time. Proper routing and quick loading and unloading will permit operation records such as presented in Table 3.

TABLE 3—RECORD OF 1 MONTH'S OPERATION OF A 3-TON 1000-GAL. TANK TRUCK

Miles Run	1,860
Days Operated	31
Hours Operated	311
Deliveries Made, gal.	262,794

Few Errors in Parts Orders

As nearly as can be calculated the percentage of time lost because of central supply station vendors not having the material on hand, and similar causes (5) is about 0.04 per cent. All orders coming from traveling inspectors or garage shops for rebuild work are handled through special automotive clerks who have been trained for 3 or 4 years. Before the orders are sent to the clerks, the bills for material must be back-checked and approved by the garage-shop superintendent. We do not tolerate mistakes on parts orders, but place the responsibility, first, on either the traveling inspector or the assembler who orders the parts; second, on the garage-shop superintendent who approves the order and, third, on the automotive clerks. A large number of field orders are placed either by telephone or telegraph direct by the garage-shop superintendent, and this expense is also carried up to our costs, as overhead. I believe that this particular kind of error is the fault of the organization ordering the parts and can assure you that such errors are infinitesimal in our organization.

Fuel Consumption Decreases with Age

A comparison of the mileage obtained per gallon of fuel on new equipment as against old equipment (6) is given in Table 4.

TABLE 4—COMPARISON OF FUEL CONSUMPTION ON NEW AND OLD EQUIPMENT

	Miles per Gal. First 10,000 Miles	Last 10,000 Miles	Total Mileage Run	Average Mileage per Gal.
Type of Equipment				
1-Ton Truck	9.0	8.6	89,600	8.9
3-Ton Truck	4.9	5.2	52,365	4.9
Passenger Car	13.5	18.6	53,214	17.2

The variance in the case of the 1-ton truck shown in Table 4 is attributed to a difference in drivers and not to any difference in mechanical conditions or roads. The 3-ton truck has never been rebuilt and still has the original pistons and cylinder-walls. Repairs to this job, including paint, lettering, repairs to cab and tank, mechanical structure and the like have amounted to $0.0275 per mile. The truck will cover 70,000 miles before it goes through its first rebuild.

I could give innumerable cases; they are all the same. The three machines for which records are given are standard today as they were originally issued by the manufacturer; no special appliances, such as carbureter, have been put on, and no changes have been made in the ignition. We get these results by service through the mechanical departments. The statistics and records are on file in the automotive department of the Continental Oil Co. in Denver, and are open to inspection by any member of the Society or any committee or delegation of the Society at any time they may wish to review them.

APRIL COUNCIL MEETING

The April meeting of the Council, which was held in Detroit on the 16th, was attended by President Horning, Past-President Crane, Vice-President Church and Councilors Rumney, Hunt and Burkhardt.

One hundred and forty-five applications for individual membership were approved; as were also seven applications for affiliate membership. The following transfers in grade of membership were made: Service Member to Member, Robert H. Kerr; Associate to Member, James E. Erskine, Frank J. Lucas and Alfred C. Torgerson; Junior to Associate, H. D. Bennett, John F. Brannigan, Hal DeWaide, Harry E. Murray, Robert A. Owerstrom, Parry Haines Paul, Charles Dix Proctor, John King Reckford, Philip Rhinelander, 2nd, and Paul C. Tietz; Junior to Member, Harlan D. Fowler, Howard B. Haskins, Jesse Silverman and Wesley B. Pusey.

The resignations of four members were accepted and five members were dropped for non-payment of dues. On April 13, 1925, 5312 names were on the rolls of the Society, including Affiliate member representatives, as compared with 5250 on the same day of 1924 and 5297 on the same day of 1923. From Jan. 1 to April 13, 1925, 297 applications for membership, including Student Enrollment, had been received, as compared with 217 received in the same months of 1924 and 306 in 1923.

The financial statement as of March 31, 1925, showed a net balance of assets over liabilities of $148,652.27, this being $2,317.53 less than the corresponding figure on the same day of 1924. The net revenue of the Society for the first 6 months of the current fiscal year amounted to $104,413.65. The operating expense in the same period was $117,715.66. The following were appointed to serve on the Standards Committee, with assignment to Divisions as indicated: O. E. Eckert, John D. Gill, W. H. Graves, C. M. Larson, H. Osmond and E. W. Upham, Lubricants Division; Stanley W. Mills, on the Motorcoach Division, and C. E. Bonnett, who was recently elected secretary and general manager of the Tire and Rim Association of America, to succeed the late G. L. Lavery, on the Axles and Wheels Division. T. H. Luckey was named to succeed B. J. Bickelhaupt as a member of the Hardwood Consulting Committee. Ernest Wooler was transferred from the Lighting and the Electrical Equipment Divisions to the Passenger Car and Motor Truck Divisions.

The Council directed that the Tire and Rim Division be reestablished as an active component of the Standards Committee, the personnel of the Division being restricted for the time being at least to engineers engaged in motor-vehicle design.

An Aeronautic Advisory Committee, with Vice-President Zimmermann as chairman, was named. It was reported that good progress had been made by a committee, of which Vice-President Church is chairman, in the matter of encouraging the holding this year of an Intercity Airplane Tour.

Automobile Design and Automotive Steels

By THOMAS H. WICKENDEN[1] *Illustrated with* DRAWINGS

ABSTRACT

WITH a view to ascertaining the specific requirements of various parts of an automobile and to determining whether alloy or carbon-steel is best adapted to meet these requirements, an investigation and analysis is made of the stresses and factors of safety in the parts; for specifying a more expensive material than is needed to perform safely the duties required, although it may increase the cost of a finished part by only a few cents, will mount into large figures when a year's production is considered.

Instead of being able to design unrestrictedly, an engineer is frequently limited by such considerations as former designs, shop equipment, jigs, fixtures, the capacity of milling machinery, and sometimes even by the size of old foundry flasks, to say nothing of the individual tastes of the president, sales manager, production manager, and other influential officials. The hardest work of the metallurgist should be directed toward the drafting-room, in order that physical requirements extremely difficult to meet in production may be avoided.

Among the topics given consideration are the stresses and factors of safety in the front axle and steering-knuckle, and in the front-axle center under maximum vertical load; the material for the axle center; the advantages of alloy-steel for heavy cars; the stresses on the steering-knuckle spindle when the springs are closed, and in the axle center and steering-knuckle when turning a corner; the reactions in the steering-knuckle and the possibility of failure of a part through fatigue and through excessive stresses due to turning corners and to side-sway; the use of oil or case-hardened gears in transmissions; the load required to break gear teeth; and the results of road-tests of transmission gears.

Analyses of 3.5 and 5.0-per cent nickel-steel are given, as are the tensile-values of case-hardened and carburized test-pieces and the comparative results obtained from them under the Izod test. The demands of rear-axle pinions, ring gears and driving shafts are set forth; and, in conclusion, attention is called to the torsional and bending stresses of shafts, the effects of the undercuts and sharp corners sometimes present in the splined portion of shafts and the increased stiffness and lighter weight that are to be secured from the use in frames of deeper and thinner sections composed of alloy-steel.

THE design of an automobile and the selection of the steels to be used in its construction are closely interwoven. The selection of the proper steel to be used in any part is influenced by many factors; there is more to it than the mere placing of an S.A.E steel specification number on the tracing of the part. The design is influenced by the sizes and the weights of the various unit parts, and these, in turn, depend on whether the part is to be made of alloy or of carbon-steel.

With the mass production of today and its thousands of duplicate parts, the specifying of a more expensive material than is needed to perform safely the duties required, although it may increase the cost of a finished part by only a few cents, will mount into large figures when a year's production is considered. But material low in first cost is not always the cheapest in the end. Metallurgists must meet engineering requirements with materials that will give the minimum cost to the finished assembly. To be on a sound economic basis, therefore, the use of alloy-steels may prove desirable because of lower costs, while at the same time improving the quality and the performance of the car.

An engineer likes to design unrestrictedly, to design in accordance with his ideal of producing the best possible machine for the purpose. Commercial considerations, however, are encountered and it is necessary to temper the design to meet them. Such things as former designs, shop equipment, jigs, fixtures, the capacity of milling machinery, and even the size of old foundry flasks, have been known to control design, much against the engineer's wish. The particular field into which the car is going, the proposed selling price, the size and annual capacity of the plant at which the car is to be produced, all are factors that influence design, to say nothing of the individual tastes of the president, sales manager, production manager and other influential officials who must be considered.

DESIGN AND THE METALLURGIST

Keeping these limiting factors in mind, the engineer finally reduces his ideas to a workable basis and center-line layouts and layouts of individual units begin to make their appearance. It is at this point that the metallurgist should do some of his hardest work in the drafting-room. How often are designs hemmed in by limits on the layout that later are impossible to change, resulting in parts, the physical requirements of which are extremely difficult to meet; or such is the design that certain parts require constant care in the hardening-room in order that they may be produced satisfactorily and the cost and loss because of scrap kept within reason!

For example, the selection of the smallest possible diameter of ball bearing for the front end of a transmission will result in thin overhanging walls of the transmission drive-pinion that later will give trouble from warping or cracking in the hardening-room. It may be a case of deciding between the extra cost of a slightly larger bearing or the probable care and trouble required on the transmission drive pinion in the hardening-room. If the smaller bearing is selected, the metallurgist has at least had a chance to enter into the matter with his eyes open; and the judicious use of radii and a gentle change of section will help reduce the difficulty to the minimum.

By entering at the designing end, the metallurgist knows the history of a piece from the beginning, can intelligently specify metallurgical limits and can assume, to a large extent, the responsibility for the machine's standing-up, that is, its freedom from breakage, and its long life with the minimum of repair. This, of course, requires an analysis of the stresses involved in each important part when considered from every possible angle.

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This is a large task, but most engineering departments have a man who specializes in these calculations and will usually welcome cooperation in applying the results.

Detailed Analysis Important

It is poor policy to specify a material for a new design merely because the material has previously been used in a similar part, or because a certain other car is using it, unless a detailed analysis has been made in each case to reduce the loads involved to unit stresses. Service records of the vital parts of an old design should be analyzed to determine whether time has proved the original proportions to be correct and, by them, to check the calculations on the new design.

To illustrate, there is a car, whose steering-knuckles are designed with so generous proportions that, although made of plain carbon-steel, they have stood-up successfully. Another company, knowing this and wishing to reduce its material cost, changed from a chrome-nickel to a carbon-steel, without considering its individual requirements; the fact that its knuckle spindle was fully 3/16 in. smaller in diameter evidently was not thought of. No difficulty was experienced for some time, but the company later entered into a siege of broken steering-knuckles, fatigue fractures showing in every case.

Many persons, and even some engineers, feel that it is impracticable to determine the size of automobile parts by calculation, especially the running-gear of a car, for they can conceive of conditions that would introduce greater stresses than those assumed in the calculation. By analyzing the stresses, however, and determining the factors of safety used in successful designs, as well as in those known to have given trouble, a method of calculation as well as the proper factors of safety can be determined.

While advocating calculation of the stresses involved, I do not wish to discredit the value of supplementary tests. The performance of parts under laboratory and road-tests and "fool stunts" may show-up conditions that have been overlooked in the calculations, and also whether sufficient margin has been allowed for the "factor of ignorance," sometimes so-called, involving both the driving public and the variation in the quality of the material used.

Consideration of a few examples will probably illustrate more fully the points I have in mind. I will go, therefore, into the method of calculating the stresses involved in the front axle and the steering-knuckle of a medium-weight car in order to determine the points at which and the conditions under which the maximum stresses occur.

Stresses and Factor of Safety in Front Axle and Steering-Knuckle

It is customary to figure the factor of safety on these parts under a static load, resulting from the rated passenger-load and the weight of the car ready for the road, that is, with the various systems filled with water, oil and gasoline. On many parts this method will show factors of safety of a fairly high order, much higher than really exist, such as those on steering-knuckles where factors of safety of from 20 to more than 40 are found, while, at the same time, some steering-knuckles give trouble in service on account of fatigue breakage. In actual use, the maximum stresses are caused by dynamic loading; and it is my contention that the stresses used in calculation and the resulting factors of safety should be figured as near these conditions as possible.

After a consideration of previous designs, it is estimated that a new car ready for the road should weigh about 2900 lb. Also, from previous data, it is found that about 45 per cent of the weight of the car is on the front wheels, which, in this case, would amount to about 1320 lb. Some of the other data that will be needed in the calculations are listed below.

Capacity of the Front Springs per Inch of Deflection, lb.	450
Normal Clearance between the Front Springs and the Frame, in.	2.75
Average Weight of Passenger, lb.	150
Static Load on the Front Axle from Passengers, Figured as One-Half Total Passenger-Load on the Front Seat, lb.	150
Total Load on the Front Wheels, lb.	1,320 + 150 = 1,470
Less Weight of Front Axle and Wheels, lb.	170
Weight on Front Axle-Pads, lb.	1,300
Weight on Each Axle-Pad, lb.	650

Stress in Front-Axle Center Under Maximum Vertical-Load

Instead of determining this stress from the normal static loading, I shall use the load required to close-up both the front springs, after the rubber bumpers have been removed; in this case, when the springs are depressed so that the frame rests on the spring clip. I have found this to be a safe assumption, if the front springs have been properly designed, for in actual trial it is necessary to strike an obstruction of considerable size in order to close-up the springs as described. After driving

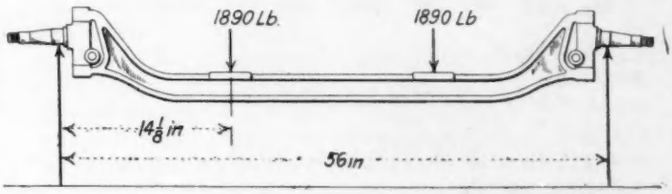


Fig. 1—The Axle Considered as a Beam with Equal Loads Applied at Equal Distances from the Ends

for some time without rubber bumpers, I found that the closing of the springs occurs only rarely, unless the front springs definitely are too weak. When the rubber bumper is present, it acts to smooth out the impact; so, I doubt whether the resulting stresses are higher than those assumed. Any attempt to figure the stresses, when the car is moving at a selected speed and hits a chuck-hole of a certain depth, or an obstruction of a certain height, leaves one hopelessly involved. The method used has been checked against a number of successful cars and has proved satisfactory in service.

From the above data the load on the front-axle pads is determined as follows:

Static Load from Weight of Car on One Pad, lb.	650
Load from Additional Deflection of the Spring, 450 × 2.75, lb.	1,240
Total Load on Each Spring-Pad, lb.	1,890

Referring to Fig. 1, the axle is a beam on which equal loads are applied at equal distances from the ends. This condition will result in the bending-moment's being at the maximum and at equal distances from the points of application of the load. As the distance from the center of the spring-pad to the line of road contact is 14⅛ in., the bending-moment in the center of the axle is

1890 lb. × 14⅛ = 26,700 in-lb.

Material for Axle Center

I will not go through the calculation of the moment of inertia of the central section of the axle; but it is at this point that a decision must be made whether the axle cen-

ter is to be of carbon or of alloy-steel. If alloy-steel, such as S.A.E. No. 3135 low-chrome nickel-steel, is to be used, the permissible fiber-stress may be considerably higher than could be used for straight carbon-steel. A smaller cross-sectional area of the axle can be used, with a correspondingly lighter weight. There are limits, however, to which this substitution can be carried; it is necessary to have a certain amount of stiffness in the axle center; otherwise, the deflection of the axle under running conditions will destroy the proper alignment of the wheels, resulting in rapid tire-wear.

The stiffness of alloy and of carbon-steel is the same; that is, Young's modulus of elasticity is about 30,000,000 lb. for each; if, therefore, an alloy-steel with smaller cross-sectional area is used, the depth of the web and the width of the flanges must be increased to secure the same stiffness. But here practical forging limitations must be considered, such as the depth of the impression that can be filled out in the dies without undue loss from scrap, the thickness or, more correctly, the thinness of the web, and the minimum draft-angles that can be used without having the work stick. Going beyond certain limitations will very materially increase the production cost.

In the axle under consideration, it is decided, because of the above-mentioned limitations, to use a cross-section having a moment of inertia on a horizontal axis of 0.886, and to apply the values that have been obtained to the flexure formula, which I find is most easily remembered in the following form:

$$My = IF$$

or

$$F = My/I$$

where

F = maximum fiber-stress
I = moment of inertia
M = bending-moment
y = distance from the axis to the extreme fiber

Substituting,

$$F = 26{,}700 \times 1.225/0.886$$
$$= 29{,}000 \text{ lb. per sq. in. maximum fiber-stress.}$$

S.A.E. No. 1040 straight carbon-steel can be heat-treated so that it will have an elastic-limit of approximately 70,000 lb., which, under the maximum load, would give a factor of safety of 70,000/29,000 = 2.41. For comparison, if the normal static load of 650 lb. were used, the bending-moment would be 9200 in-lb. and the extreme fiber-stress, 12,700 lb. per sq. in., showing a factor of safety of 5.5. Comparison of these values with those similarly calculated in former practice will show them to be about the average and to be ample.

Alloy-Steel for Heavy Cars

On a heavier car, say from 3000 lb. up, the axle center can be designed so as to increase the depth of the I-beam and the width of the flanges. Sufficient stiffness can thus be secured and the foregoing limitations observed so that considerable saving in weight can be made by taking advantage of the greater strength of alloy-steel.

A tubular design of the front-axle center lends itself much better to requirements of stiffness of section, so that a very lightweight axle can be made with 3.5 per cent nickel-steel tubing, heat-treated. This is especially desirable in cars with four-wheel brakes, as front-wheel brakes introduce high torque-moments in the axle that an I-beam section is not nearly so well suited to resist as is a tubular section.

The desirability of light unsprung weight will, I think, be admitted without challenge, when easy-riding properties, long tire-wear and gasoline economy are considered. I have heard it stated that 1 lb. less of unsprung weight will reduce the wear and tear on the tires and increase the mileage as much as will a reduction of from 10 to 15 lb. of sprung weight. So, we find that in the larger passenger-cars and in the truck field, 3.5-per cent nickel and chrome-nickel steel front-axle centers are extensively used.

Stresses on Steering-Knuckle Spindle When Springs Are Closed

Continuing the calculations, the vertical load on each spindle, of course, amounts to 1890 lb. plus one-half the weight of the axle center and the weight of the steering-knuckle up to the spindle, which, in this case, is figured at 30 lb., making a total load of 1920 lb. The size of the spindle used is influenced largely by certain standard sizes of ball or roller bearings. The front-axle layout on which these calculations were originally based called for a roller bearing having an inside diameter of 1-5/16 in. and determined the size of the knuckle spindle. Furthermore, the center-line of wheel contact came within ⅛ in. of the shoulder of the spindle; hence, with only a vertical load on the axle, the highest stress on the spindle is from straight shear. The 1-5/16-in. diameter gives a cross-sectional area of 1.352 sq. in. and, dividing the load of 1920 lb. by the area, gives a shear load on the spindle of 1420 lb. per sq. in., which, in the case of S.A.E. No. 1035 steel, would give a factor of safety of about 25 or 30 to 1. If a normal static load of 690 lb. is used, the factor of safety will be between 60 and 80.

Stresses in Axle Center and Steering-Knuckle When Turning a Corner

A consideration of the stresses in the axle center and the steering-knuckle, when turning a corner, will result in finding some entirely different stresses and factors of safety. In turning a corner, the car, owing to its inertia, tries to continue in its original direction of motion, but the wheels' being turned at an angle introduces a side-thrust. This side-thrust, under normal conditions, reaches the maximum when the momentum of the car is greater than the side-thrust caused by the friction between the tire and the road, and results in a skid. The effect of this side-thrust on the axle and the steering-knuckle is multiplied by a lever-arm equal to the distance from the part to the ground, which, in the case of the steering-knuckle, is about one-half the diameter of the tire.

Returning to the case at hand, the weight on the front wheels with a full passenger-load, as previously determined, was 1470 lb.; using a coefficient of friction between rubber and brick of 0.65, the force necessary to skid the front wheels would be equal to $1470 \times 0.65 = 955$ lb. It is assumed that the center of gravity of the car is 28 in. above the ground, as indicated in Fig. 2.

Taking the moment about R_2 and solving the force acting at R_1 give the following equation:

$$(1470 \times 28)/56 + (955 \times 28)/56 = 1212 \text{ lb. at } R_1$$

Total Load, lb.	1470
Less Force Acting at R_1, lb.	1212
Vertical Load Acting at R_1, lb.	258
Skidding Reaction at R_1, lb. $= 1212 \times 0.65 =$	788
Skidding Reaction at R, lb. $= 258 \times 0.65 =$	167

Considering the axle first, there is a reaction due to the weight of 1212 lb. and, when considered as acting about the center of the axle at the spring-pad, it is in a clockwise direction, acts through a lever-arm of 14⅛ in., and gives a moment of

$$1212 \times 14\tfrac{1}{8} = 17{,}100 \text{ in-lb.}$$

But the side-thrust of 788 lb. is acting in the opposite direction through a lever-arm of 12 in., giving a moment of 9450 in-lb. The resulting moment is 7640 in-lb., or less than when under static loading.

Reactions in Steering-Knuckle

Considering the steering-knuckle, the side-thrust of 788 lb. is acting through a lever-arm of one-half the diameter of the tire, or 16.5 in. from the center of the spindle, giving a moment of 788 × 16.5 = 13,020 in-lb., acting in an anti-clockwise direction; whereas, the reaction, due to the weight of 1212 lb., is acting through a lever-arm of ⅛ in. and in a clockwise direction, giving a moment of only 152 in-lb. The resulting moment is

$13{,}020 - 152 = 12{,}868$ in-lb.

$d = 1\ 5/16 = 1.3125$

$d^3 = 2.96$

$f = My/I$

I = moment of inertia = $\pi d^4/64 = 0.146$

M = turning-moment = 12,868 in-lb.

y = distance from axis to extreme fiber = $1.3125/2 = 0.6562$.

f = fiber-stress = $(12{,}868 \times 0.6562)/0.146 = 57{,}750$ in-lb.

If the steering-knuckle were made of S.A.E. No. 1035 straight carbon-steel, heat-treated, and drawn to from 1050 to 1100 deg. fahr., it would have the following properties, as taken from the S.A.E. curves.

Tensile-Strength, lb.	94,000
Yield-Point, lb.	65,000
Reduction of Area, per cent	58
Elongation, per cent	27

Considering the yield-point gives a factor of safety against bending to a permanent set of 65,000/57,750 = 1.12 which is not enough. But, when the stresses in the same spindle were calculated under the maximum vertical loading, the factor of safety was from 25 to 30 and, under normal static load, from 60 to 80. This brings out very forcefully the necessity of analyzing the stresses under all possible conditions. A large percentage of the recurring breakages encountered by an automotive laboratory is found to be of a fatigue nature. This type of fracture is unmistakable; it invariably starts from one or more points, progressing by small increments, leaving a line at each stopping-point that often resembles a contour line on a map. The solid cross-sectional area finally is greatly reduced. The fatigue crack gives a notch effect to the piece, so that the failure of the remaining area is sudden and the fracture resembles that of a notched impact-specimen.

Failure Through Fatigue

The design of a part should be studied with reference to its possible failure through fatigue. Many valuable data are gradually accumulating in the literature of the subject. To make them available for engineering use, an attempt has been made to coordinate the fatigue properties with the commonly determined mechanical properties of the steel. It has been shown that, if a heat-treated carbon-steel is stressed by bending in alternately opposite directions and the deflection is limited so that the extreme fiber is stressed within approximately 45 per cent of its tensile-strength, the piece can be flexed indefinitely without breaking. The allowable stress is called the fatigue-endurance limit; and its ratio to the ultimate-strength of the piece, the fatigue ratio.

In considering the fatigue failure of steel, it is necessary to remember the influence of tool-marks, scratches, undercuts, sharp corners and threads in producing highly localized stresses; also the effect of non-metallic inclusions and segregation that may make an easy starting-point for a fatigue crack. No connection is apparent between fatigue, endurance and ductility, unless we conclude that the higher fatigue-ratio of heat-treated alloy-steels over straight carbon-steels of the same

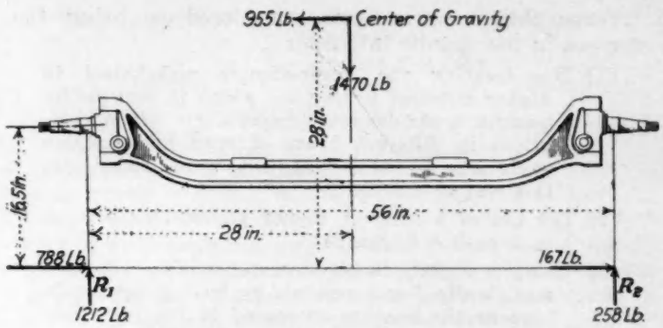


Fig. 2—Diagram Showing the Stresses in the Axle Center and the Steering-Knuckle When Turning a Corner

strength is due to the higher ductility of the former, which minimizes the effect of localized stresses. Higher ductility generally insures good impact-values, a suddenly applied over-load, resulting in bending.

Steering-knuckles are subjected to alternative bending-stresses due to turning corners in both directions and to side-sway in rutty roads, so that the possibility of their breaking through fatigue must be considered. In the case under consideration, with a tensile-strength of 94,000 lb. for straight carbon-steel, the endurance-limit stress would be 45 per cent of that, or 42,300 lb. per sq. in. But, as figured, there is a possible stress of 57,750 lb. that does not give any factor of safety on the fatigue-endurance limit, as the ratio is less than unity: 42,300/57,750 = 0.73.

This is a condition that in time would result in failure. It illustrates the approximate condition met with in the example previously cited, in which straight carbon-steel was substituted for chrome-nickel steel and in which the spindle invariably broke after from 8000 to 10,000 miles.

Stresses Due to Turning and to Side-Sway

To correct this condition, there are two alternatives: (*a*) to increase the diameter of the spindle and lower the unit fiber-stress, which would mean larger and more expensive wheel bearings and a larger-diameter wheel-hub, resulting in added weight; or (*b*) to meet the stress by the use of alloy-steel. Since the size and the capacity of ball and roller bearings progress in steps, a differential of one or two steps can be made between the size required for a steering-knuckle designed for carbon and one for alloy-steel; hence, the use of alloy-steel in steering-knuckle spindles proves to be purely a matter of economy.

The question arises, What stresses and factors of safety are suitable to use? Following the above-outlined method of figuring, the cars that have been manufactured for some time are free from spindle breakage; in a model built in the early days and originally equipped with carbon-steel steering-knuckles, the breakage was frequent. When the steel specification was changed to an alloy-steel, the breakage was greatly reduced but was not entirely eliminated until the knuckle had been redesigned with a larger spindle. The factor of safety is based on a yield-point of 106,000 lb. per sq. in., which is the average result of a number of tests on S.A.E. No. 3135 steel, water-quenched and drawn to from 1050 to 1100 deg. fahr. For heat-treated alloy-steel, the fatigue-endurance stress is about 50 per cent of the tensile-strength; in this case, 50 per cent of 132,000, or 66,000 lb. per sq. in.

Returning to the case under consideration, the fiber-stress of 57,750 lb. per sq. in. is higher than has been successfully used with steels of 106,000-lb. per sq. in. yield-point, showing a factor of safety of 1.84 or, on fatigue, of 1.14.

Three things were again considered to bring the stresses in the spindle into line:

(1) Heat-treating the lower-chrome nickel-steel to higher physical properties, which is possible by using a lower drawing-temperature. When variations in different heats of steel and possible variations in heat-treatment were considered, this was abandoned

(2) The use of a steel of higher physical properties, such as S.A.E. No. 3435

(3) Using a slightly larger-diameter spindle, which it was finally found possible by having the inside bore or the bearing increased to 1⅜ in. This reduced the amount of stress to 50,400 lb. per sq. in., giving a factor of safety, or yield-point, of 2.10 and an endurance-limit of 1.31, which comes into line with the figures in the table referred to above

Transmission Gears

An important question to decide, from both an engineering and a metallurgical standpoint, is whether to use oil-hardened or case-hardened gears; both have their advantages and drawbacks.

Oil-hardening steel requires considerable care in forging and annealing, and must be machined slowly; whereas, case-hardening steel is forged and annealed with ease and can be machined rapidly. In fact, the more rapid the cutting, the better will be the finish within certain limits.

The final heat-treatment of the oil-hardened stock is comparatively cheap and simple, and gives the minimum warpage, especially when handled by the "hump" method. Carburizing is not only expensive but requires constant care, to get uniform results, and a more complicated final heat-treatment.

Until the fairly recent development of grinding the hardened gear-teeth to form, the oil-hardened gear was the more quiet. With ground teeth, however, there is no choice from the standpoint of quietness.

The oil-hardened gear has a higher tooth-strength, but a lower amount of unit resistance to pitting and to wear than has the case-hardened article.

Load Required to Break Gear Teeth

The first statement is borne out by the following tests made by one of the prominent transmission companies. The figures show the range of loads required to break out a tooth on similar gears of 6-8 pitch, 1-in. face, with the load applied at the pitch line:

3.5-per cent nickel-steel, case-hardened, lb.	20,000 to 22,000
S.A.E. No. 3250 chrome-nickel steel, oil-hardened, lb.	40,000 to 45,000

The second statement regarding pitting is not made in condemnation of oil-hardened gears, but simply by way of emphasizing the necessity for having the proper tooth-contact to bring the unit load below the pitting-point. The pitting of gears in service is, I believe, one kind of demonstration of fatigue failure. At the line of contact between two gear-teeth, the surface metal is being compressed and expanded at each tooth contact and, when within its elastic-limit, is acting according to Hooke's law of elasticity. Under this condition, we do not have a reversal of stresses as in alternating bending fatigue, but a compression fatigue ranging from zero to full load. Judging from a review of the literature, the fatigue-limit for repeated compression under this condition is about 50 per cent of the tensile-strength. A test of an S.A.E. No. 2345 3.5-per cent nickel oil-hardened gear steel shows the following when quenched from 1380 deg. fahr. in oil and drawn to 425 deg. fahr.

Analysis:	
Carbon, per cent	40
Manganese, per cent	52.00
Nickel, per cent	3.52
Ultimate-Strength, lb. per sq. in.	270,000
Elastic-Limit, lb. per sq. in.	208,000
Elongation, per cent	13.0
Reduction of Area, per cent	37.5
Brinell Hardness	512

This would give a fatigue value of approximately 135,000 lb. per sq. in. and an elastic-limit of 208,000 lb. per sq. in. As near as I can calculate, the surface unit-compression stress under maximum loading in most passenger cars will run near the elastic-limit, or considerably above the compression-fatigue limit; and the fatigue failure expresses itself by the small particles of fatigue metal coming out and forming pits. When a gear is being worked near its limit, imperfections in the steel, such as segregation, non-metallic inclusions or foundry sand from an imperfectly cleaned transmission-case, may accentuate the results. The actual hardness of the metal, as it gives increased resistance to wear and is an expression of increased tensile-strength and, therefore, of fatigue limit, is, of course, desirable. So, in a case-hardened gear, these points are secured without sacrificing the impact properties of the tooth as a unit. Proof of these statements has been brought out by a number of laboratory and road-tests, as well as by keeping service records of cars in which changes have been made.

Road-Tests of Transmission Gears

Road-tests were run on two cars that were similar, with the exception that the transmission gears of one were S.A.E. No. 2345 3.5-per cent nickel-steel, oil-hardened, with an average tooth-hardness of about 72 to 74; the other, S.A.E. No. 2320 3.5-per cent nickel case-hardened steel with a hardness of about 85. These cars were run for 2 hr. of each test, or about one-third the total time, on sand roads in low and in second gear. After 9000 miles, the oil-tempered gears showed pitting; whereas, the case-hardened gears were in perfect condition after 30,000 miles. This specific test was further substantiated by service records, as gears were returned on account of pitting while using the oil-hardened steel; but this trouble was entirely avoided when case-hardened gears were adopted. A wider face, or other means of reducing the unit tooth-pressure, would undoubtedly have corrected the trouble, but that meant an entire redesigning of the transmission. A car using the same tooth-face and pitch, and having approximately the same pitch-diameter, but being of lighter weight and having lower engine-torque, has experienced no difficulty with S.A.E. No. 2345 oil-hardened gears.

Another prominent car-builder who made extensive tests of oil-hardened gears got the best results with S.A.E. No 3250 chrome-nickel steel. Service records, however, showed that a slight amount of trouble from pitting was experienced in mountainous country and a reinvestigation was made. An engine, driving through the second speed of transmission and thence to a dynamometer and operating at a load and speed equivalent to driving a fully loaded car up a 14-per cent grade in second speed at 18 m.p.h., required about a three-quarter throttle-opening. The oil-hardened gears became noisy after 12 or 13 hr. and failed on account of tooth breakage after 25¾ hr., the equivalent of 500 miles. The 5-per cent nickel-steel case-hardened gears, after operating for 7 days and nights, or 166 hr. continuously, were quiet and

were found to be in perfect condition. This was equivalent to about 3000 miles of driving in second speed and at the same time elevating the car a vertical distance of about 418 miles.

The compositions of the 3.5 and 5.0-per cent nickel-steel are given in Table 1. Some of the results obtained are shown in Tables 1, 2, 3 and 4.

In both cases 3-in. rod stock was forged down to 1 in., cut off in 6-in. lengths and treated as follows: (*a*) heated to 1675 deg. fahr. and air-cooled, (*b*) heated to 1580 deg. fahr. and water-quenched and (*c*) heated to 1100 deg. fahr. and air-cooled. These bars were machined to 7/8-in. diameter and treated as follows: (*a*) heated to 1550 deg. fahr. and oil-quenched and (*b*) heated to 1350 deg. fahr.

TABLE 1—COMPOSITION OF 3.5 AND 5.0-PER CENT NICKEL-STEELS

Constituents	3.5-Per Cent Nickel-Steel, Per Cent	5.0-Per Cent Nickel-Steel, Per Cent
Carbon	0.180	0.170
Manganese	0.410	0.450
Phosphorus	0.015	0.012
Sulphur	0.014	0.017
Nickel	3.640	4.680
Silicon	0.260	0.240

and oil-quenched. These were machined to 0.505-in. test-pieces.

Another set was machined to 0.520 in. and treated as follows: (*a*) carburized 0.035 in. and cooled in box (*b*) heated to 1550 deg. fahr. and oil-quenched and (*c*) heated to 1350 deg. fahr. and oil-quenched. These were then ground to 0.505-in. test pieces.

Impact bars were machined to the finished size, the groove was milled and the notch cut; they were then treated as follows: (*a*) carburized to 0.035 in. and cooled in box, (*b*) heated to 1550 deg. fahr. and oil-quenched, (*c*) heated to 1350 deg. fahr. and oil-quenched and (*d*) drawn at 400 deg. fahr. The hardness of the case on the 3.5-per cent nickel-steel was a little lower than on the 5-per cent nickel-steel pieces.

Drawing at 400 deg. fahr. raised the impact value on the 5-per cent nickel-steel from about 14 ft-lb. to the figures given in Table 4.

Rear-Axle Pinions and Ring-Gears

The rear-axle pinion must meet more severe conditions of wear, strength, toughness and quietness than any other part of the car. The ring-gear is influenced by the same factors: the greater number of teeth reduces the wear factor; the different tooth-contour gives a stronger tooth and, at the same time, slightly reduces the toughness required; and the demand for quietness is the same, making desirable a steel with the minimum warpage in heat-treatment.

Some metallurgists take advantage of the difference in the properties required and use a less expensive steel in the ring-gear than in the pinion, but it is common practice to use the same material in both parts. To the best of my knowledge, an alloy-steel is used in the pinions of all cars, although a straight-carbon or a low-alloy steel is used in the ring-gear of some light-weight cars. A 0.5 or 1.5-per cent nickel-steel is used by some.

TABLE 2—AVERAGE TENSILE-VALUES OF CASE-HARDENED TEST-PIECES

Material	3.5-Per Cent Nickel-Steel	5.0-Per Cent Nickel-Steel
Ultimate Tensile-Strength, lb. per sq. in.	110,308	188,875
Elastic-Limit, lb. per sq. in.	76,017	131,192
Elongation in 2 In., per cent	27.34	14.32
Reduction of Area, per cent	63.10	49.70
Brinell Hardness	217	375

TABLE 3—AVERAGE TENSILE-VALUES OF CARBURIZED TEST-PIECES

Material	3.5-Per Cent Nickel-Steel	5.0-Per Cent Nickel-Steel
Ultimate Tensile-Strength, lb. per sq. in.	105,125	204,525
Elastic-Limit, lb. per sq. in.	80,500	172,500
Elongation in 2 In., per cent	12.00	5.47
Reduction of Area, per cent	18.50	8.50

The lower quantity especially does not give much increase in strength, but it greatly facilitates the ease of handling the part in the heat-treating department; the grain growth is retarded during the carburizing process and the case responds to hardening much more readily after it has been oil-quenched. The saving in heat-treatment more than offsets the extra cost of the steel. S.A.E. Nos. 2315 and 2320, 3.5-per cent nickel carburizing steels are commonly used. Good impact-values combined with medium hardness of the core can be developed, thus giving support to the case, which, at the point of contact, is subjected to high pressures. If the core is too soft, it may cause failure of the case owing to a slight flow of the core-metal underneath.

This steel responds to heat-treatment at temperatures from 75 to 100 deg. fahr. lower than does straight carbon-steel, which is an important factor in preventing scale formation during the heating and warping in hardening. The alloy retards grain growth during heating; so, if the carburizing temperature is not too high, a single hardening heat-treatment can be successfully used. This is especially applicable to ring-gears. What has been stated regarding the properties of 3.5-per cent nickel-steel is still further emphasized by the use of S.A.E. No. 2512 5-per cent nickel-steel, which was discussed for case-hardened transmission-gears and probably represents the highest type of steel obtainable for rear-axle pinions and ring-gears.

Rear-Axle Driving-Shafts

The use of alloy-steel instead of carbon-steel for axle driving-shafts has resulted in a saving of approximately 28 per cent in the weight of the part. This saving is not confined to the shaft itself but the smaller-diameter shaft allows the use of smaller-diameter bearings, a bearing housing at both the wheel and the differential, and a smaller-size axle-housing. The smaller-diameter bearings, as well as the smaller amount of material used in the other parts, have resulted in a saving in cost that more than counterbalances the higher cost of the alloy-steel used in the shaft. The net result is a lighter weight and cheaper axle for the same load-capacity. Proof of the amount of saving in the weight of the axle can be developed easily from the torsion formula for round shafts.

TABLE 4—RESULTS OF IZOD IMPACT-TEST ON CARBURIZED AND HARDENED TEST-PIECES DRAWN AT 400 DEG. FAHR.

3.5-Per Cent Nickel-Steel, ft-lb.	37
5.0-Per Cent Nickel-Steel, ft-lb.	33

$$M = SJ/C = S\pi d_c^3/16$$

where

$C = d/2$ = distance from the axis to the extreme fiber
d = diameter
$J = \pi d^4/32$ = polar moment of inertia
M = twisting-moment, or torque
S = maximum unit shearing-stress

The twisting-moment acting on a carbon-steel or an alloy-steel axle would be the same.

$$S_c \pi d_c^3/16 = S_a \pi d_a^3/16$$
$$S_c/S_a = d_a^3/d_c^3$$

The weights of the two shafts are proportional to the squares of the diameters.

$$W_c/W_a = d_c^3/d_a^3$$
$$d_a^3/d_c^3 = W_a \sqrt{W_a/W_c} \sqrt{W_c}$$

Substituting this value of d_a^3/d_c^3 in the above equation

$$S_c/S_a = W_a \sqrt{W_a/W_c} \sqrt{W_c}$$
$$S_c^3/S_a^3 = W_a^3/W_c^3$$

For convenience in figuring, I will substitute the values of the yield-points of S.A.E. No. 1045 and S.A.E. 3140 steels, both oil-quenched and drawn at 1000 deg. fahr. The S.A.E. tables give, for No. 1045 steel, a yield-point of 70,000 lb. per sq. in. and for No. 3140, 115,000 lb. per sq. in.

$$W_a^3/W_c^3 = (70{,}000)^2/(115{,}000)^2$$
$$= 0.3705$$
$$W_a/W_c = \sqrt[3]{0.3705}$$
$$= 0.7180$$
$$W_a = 0.7180\ W_c$$

The saving in weight is 28.2 per cent.

In the larger-size passenger cars and motor trucks, the shafts become of such diameter that the depth-hardening properties of the steel used must be considered, so that the use of alloy steel becomes more essential and the higher-chrome nickel-steels, such as the S.A.E. Nos. 3200, 3300 and 3400 series, are well adapted to this purpose.

Design of Shafts

The design of the shaft itself is worthy of considerable study, for there is a combination of torsional and bending stresses, except in the case of a truly full-floating axle, in which torsional stress is the principal consideration. To limit the discussion, I will consider especially the small section of the shaft and its relation to the spline end, where most of the difficulty is experienced.

C. W. Spicer[2] brought out the fact that the splined portion of a shaft has an elastic-limit considerably lower than that of a plane shaft having a diameter equal to the base-circle of the spline. In the case of a spline of 1.587-in. diameter, with 1.315-in. base-diameter, the elastic-limit of the spline section was 20 per cent lower than that of a plane shaft of 1.315-in. diameter.

Considering the sharp corners and the undercuts that are sometimes present at the base of the spline, with resulting highly localized stress, the diameter of the shaft next to the spline should be smaller than the base-diameter of the spline to resist torsional fatigue properly. A study of broken shafts will bear out this statement. Shafts having the base-diameter of the spline section, or a larger diameter, invariably show a fatigue break either in the spline or at the junction. The mechanics of this failure seems to be the production of radial longitudinal cracks at the base of the splines that reduce the torsional resistance until the shaft finally shears.

The size of the smallest section can be based on the maximum engine-torque, operating through the greatest transmission reduction, which is generally the reverse gear and the rear-axle reduction. A second method is based on the maximum tractive-effort that can be developed because of the friction component between the rear tires and the road when a car is fully loaded. Returning to the car under consideration, the load on the rear wheels of a fully loaded sedan would be 2400 lb., or 1200 lb. on each wheel. Using a coefficient of friction of 0.65, we have

Torque = Load × Coefficient of Friction × One-Half the Diameter of the Rear Wheel
= 1200 × 0.65 × 16.5
= 12,880 in-lb.

This gives an extreme fiber-stress with a 1 3/32-in. axle shaft of 50,200-lb. per sq. in. elastic-limit.

Using the S.A.E. tables for figuring torsional shafts is not very satisfactory, as it is necessary to asume a ratio between the tensile elastic-limit and the torsional elastic-limit of the extreme fiber. These ratios vary over a wide range depending on the material and the heat-treatment. Some values that I have secured with different steels, oil-quenched and drawn, are given in Table 5. These tests were run on sections between 1 and 1¼ in. in diameter.

TABLE 5—PROPERTIES OF S.A.E. STEELS

S.A.E. No.	Brinell Hardness	Shearing-Stress at Elastic-Limit, Lb. per Sq. In.	Ultimate Shearing-Stress, Lb. per Sq.In.
3135	286	66,200	124,000
3135	302	74,200	120,200
3135	331	91,500	136,000
3135	364	89,700	142,800
3135	375	92,000	147,000
3435	358	127,000	168,000 (Average of 6 tests)

Tests by McAdam[3] on heat-treated 3.5-per cent nickel-steel show a ratio between the average torsional-strength and the alternating torsional endurance-limit of about 0.45. If the shaft is heat-treated to Brinell limits of 364 to 402, the following approximate torsional properties can be secured:

Ultimate Torsional-Stress, lb. per sq. in.	140,000
Elastic-Limit, lb. per sq. in.	89,000

This would give a torsional endurance-limit of 63,000 lb. per sq. in. With a maximum fiber-stress from tractive reaction of 50,200 lb., this gives a factor of safety on the elastic-limit of 1.775 and on fatigue of 1.26. Checking this with other cars, I find the facts shown in Table 6 come into line.

TABLE 6—COMPARATIVE FACTORS OF SAFETY AND ELASTIC-LIMITS

Car No.	1	2	3	4	5
Half Diameter of Tire, in.	17	16½	16	16	16
Minimum Diameter of Driving Shaft, in.	1 1/16	1 3/32	1 1/16	1 1/16	1 1/16
Weight on One Rear Wheel when Loaded, lb.	1,300	1,200	1,250	1,100	1,700
Torsional Reaction with Coefficient of Friction = 0.65, lb.	14,400	12,900	13,000	11,450	18,800
Fiber Stress, lb. per sq. in.	61,200	50,200	55,200	48,600	58,400
Factor of Safety on Elastic-Limit	1.46	1.77	1.62	1.83	1.52
Factor of Safety on Endurance	1.03	1.26	1.14	1.30	1.08

Car No. 1 gave trouble if the hardness of the shafts was allowed to drop too low. Table 7 indicates that the life is about proportional to the hardness, as was shown by a number of broken shafts that were brought to my attention.

TABLE 7—RATIO OF MILEAGE TO HARDNESS OF SHAFTS

Brinell Hardness	Mileage at Time of Breaking of the Shaft
228	9,300
277	11,000
286	15,000

[2] See The Journal, February, 1921, p. 129.

[3] See *Proceedings of the American Society for Testing Materials*, vol. 23, part 2, p. 56.

Frames

In designing a frame for a passenger car, especially if it is to be used with a closed body, stiffness and rigidity are two of the main considerations. As Young's modulus of elasticity is practically the same for carbon and for alloy-steel, no gain in stiffness can be made by substituting alloy for carbon-steel. Stiffness of the frame can, therefore, be secured most efficiently by using deeper sections. Strength can be secured by using thinner sections made of alloy-steel, resulting in a saving in weight. Practical considerations, however, have shown that a frame having a thickness of about ⅛ in. is the practical minimum; with a thinner section, trouble will be encountered in fabrication, and slight nicks or imperfections in the edge of the frame may cause localized stresses.

So, on light and medium-weight cars, carbon-steel has proved satisfactory. There is, of course, a limit to the permissible depth of section, so that it has been found desirable to use nickel or chrome-nickel steel frames in the heavier cars. In trucks, in which a slight deflection of the frame is not objectionable, heat-treated nickel or chrome-nickel frames are common and result in considerable saving in weight and increased durability.

There has been some criticism and discussion recently of the value of the physical-property charts of the S.A.E. steels. In my opinion, they are the most valuable set of data in the S.A.E. HANDBOOK today and the HANDBOOK is the authority of the automotive and allied fields. Where else can authentic data of this nature be secured? They are conservative by the very nature of the method of compilation, which is what an engineer wants in designing. Higher values obtained in actual practice give an added factor of safety but, for the occasional piece of inferior, or poorly heat-treated, steel that gets by the inspector, there is still sufficient section to guarantee safety. Other information should be added to the S.A.E. data sheets, such as the physical-property curves to cover lower drawing-temperatures of the steels used for oil-hardened gears, which are sometimes tempered below 400 deg. fahr. The torsional values of the various steels under different treatments would also be a valuable addition. The fatigue-endurance values of the various steels for different heat-treatments are something to look forward to, as they will pay an ever-increasingly important part in engineering calculations, as further data on the subject are developed.

STANDARDIZATION

IN its modern sense, standardization is the final result of an intensive study applied to some specific subject. We review the entire series of influencing factors relative to a standard, and then make a complete economical, well unified solution of the problems. It must be a forced evolution guided by practical common-sense. Unless standardization is pursued in this light of today, the solution will be temporary and result in the same unfortunate handicaps that have developed in the past under a like set of conditions. We can follow two roads in this work; first, the commonly used one, that of drifting under economic pressure from one approximate solution to another a little better.

Much of this class of work might be better termed simplification or elimination. Imitation is often mistaken for standardization. There are also the cut-and-try methods in which one partial solution drives us on to another, until an approach is finally made to what is about right. By this drifting method the ultimate solution will seldom be a completely correct one. We are continually compromised, and often rightly so, by consideration for repairs, stock on hand, equipment for manufacture, resistance to change and similar factors, all of which simply emphasizes the extreme importance of starting and proceeding aright.

The other road, and the right one, is that of intensive and careful study before establishing a standard, or proceeding to a change, thus making the number of changes the minimum, but advancing, nevertheless, with greater ultimate speed toward the desired end. This correct procedure is supported by informational data and records, which simply means that every factor and use is made of all practical knowledge and processes which apply to attaining a practical and scientific solution. The rapid rise in stability and the huge profits of the automotive industry in America have resulted in no small degree from its adoption almost from the start of this more scientific method.

Improvements in any standards must be made when a new analysis shows this to be desirable. If such a program reduces the number of such changes to a respectable minimum, it has done its part; if it stabilizes the procedure enough to permit mass production to take place over a reasonable period, it has fulfilled its mission.

The advantages gained by intensive standardization can be summarized by these few sentences:

(1) It establishes a minimum and uniformly graded series of *Materials*, both raw and semi-finished, which will meet the manufacturer's requirements according to the products and processes given preference

(2) It results in savings due to uniformity and speed in manufacture with the minimum variety and number of processes. It reduces manufacturing supervision

(3) It results in reduction of inventories in both materials and manufacturing equipment. This carries with it simplified clerical work all along the line

(4) Important reductions in *Labor Costs*, in both manufacture and assembly, accrue

(5) Increased speed and uniformity in *Designs* result also. Standardization substitutes group judgment for individual judgment. It reduces experimental work and try-outs, and assures sensible graded sizes. It reduces the percentage of time taken on designs or on details. The saving can be better devoted to the more important general problems. This has a wholesome effect on initiative

(6) Sensible standardization facilitates *Sales* by pleasing customers. It furnishes effective and convincing argument. It warrants higher prices, since it raises the quality of the product. It reduces sales resistance. Repair stocks and handling charges are reduced

(7) It reduces needless *Waste* from every angle

In the past American engineering progress has resulted from the application of supreme mechanical genius. This is now giving way to the powerful combination of mechanical genius and applied science. We see, on every hand, the great commercial organizations giving more and more leeway to research.—From an address by O. B. Zimmerman, International Harvester Co.

POWER ALCOHOL FROM TUBERS AND ROOTS

THE Fuel Research Board has published a memorandum on fuel for motor-vehicle transport, prepared by Sir Frederic Nathan, in which it deals in detail with the possibilities of using potatoes, mangolds or Jerusalem artichokes as raw material for producing power alcohol. In addition to a survey of results obtained elsewhere, this memorandum gives an account of various experiments carried out at different times from 1917 to 1924, with the object of determining the yield of the tubers and roots per acre and the production of alcohol to be obtained from them.

So far as concerns potatoes, the conclusion reached confirms that of the Departmental Committee on Industrial Alcohol, which reported in 1905 that a profitable industry could not be founded on the use of potatoes as a material for distillation. Since that date proposals have been made for the intensive cultivation of a potato of high starch-content, and the distillation of alcohol in cooperation with the growers; but it is thought highly unlikely that such measures would have any real chance of commercial success. Even in Germany, where for some years before the war, alcohol was produced from potatoes on a large scale, the industry appears to have been successful only through the effect of a State subsidy. From furnishing 95 per cent of the alcohol produced in Germany, its production has fallen to 15½ per cent, and the balance of opinion even in that country is that, while a greater use of alcohol as a fuel for internal-combustion engines is desirable, potatoes are too valuable as foodstuffs to be used economically for the purpose. At present wholesale prices for potatoes in Great Britain, they would cost as raw materials about 7 shillings per gal. of alcohol.

The prospect of mangolds is less hopeless. They are easier to grow, harvest and store; are not so liable to disease and failure and their carbohydrates are in the form of sugar and thus yield alcohol more simply than it can be obtained from the starch of potatoes. Mangolds would yield raw material at a little over half the cost of potatoes per gallon of alcohol; still not an encouraging basis for manufacture, even when allowance is made, as with all these products it has to be, for the use of residues in the manufacture of feeding-stuffs.

Artichokes, a Possible Source of Fuel

The most hopeful of the three crops is the Jerusalem artichoke which, in addition to its tuber below ground, has above ground a plant some 8 or 10 ft. high. It belongs to the natural order Compositae and is of the sunflower genus. It will grow in almost any well drained soil, can be left in the ground over winter without injury, and for a number of years will go on propagating itself from what is left in the ground without loss of yield, so that no labor is needed except for harvesting, until fresh fertilizers, or possibly at intervals fresh seed tubers, have to be applied. The yield seems to vary widely, and the chemical composition of the tuber is not the same in autumn as in spring, so that no very definite figures are given for the yield of alcohol per acre; but the considerable experience gained not only abroad but by experiments at the Royal Naval Cordite Factory and elsewhere show that it is better than is to be expected from the other crops. Experiments have been made and seem still to be in progress on the best conditions for its alcoholic fermentation. It has been found, moreover, that when the carbohydrates are hydrolized and their concentration suitably reduced considerable quantities of a mixture of butyl alcohol and acetone can be obtained by the action of the bacillus butylicus, or by the simultaneous action of yeast with the bacillus a 70-per cent mixture of ethyl alcohol with the mixed solvent. The residues from the distillation of the tubers seem to give about a ton of the good feeding-cake per ton of tuber, and the stalks of the plant when suitably treated yield about 12 per cent of a pure and resistant cellulose, which is said to be very suitable for special purposes. It is interesting to observe that the average yield, some 10 to 12 tons per acre, is higher than the figures given for Germany, Switzerland and the United States, though a little lower than yields obtained in France. The widest variation is in Queensland, where figures of from 8 to 30 tons per acre have been obtained. Whether the discrepancies are due to the chemical or the bacterial contents of the soil, to the effect of sunlight or temperature, or to other circumstances does not seem to have been determined.

Mineral or Vegetable Fuels

The production of power alcohol is doubtless not the most immediate means to be taken to relieve the demand for fuel, and its most economical source may even be found ultimately in some of the luxuriant tropical growths within the Empire, at present best known as pests. Looking, however, at the fuel question, or questions, very broadly, the dominant fact is that almost all the fuel supplies at present used are what lawyers call wasting securities; in which trust investments may not be made, if at all, without considerable safeguards for getting out of them. As mineral fuels grow dearer, the advantage of fuels of vegetable origin must become accentuated, and those that can be obtained from crops which renew themselves once a year, or oftener, are particularly attractive from the economic point of view. It is therefore satisfactory to know that the subject of the production of power alcohol continues to receive attention, particularly when it is given in investigations as prudent and carefully conducted as are to be expected from the Fuel Research Board.—*Engineering* (London).

CULTURAL EDUCATION FOR ENGINEERS

THE imagination of the engineer should be equal to that of the novelist, the artist, the poet or the preacher, where thought comes in the planning of work, and in many respects the work of all these creators is the same in the development of the complete whole. The engineer is not an artisan in this work, although he constructs. But he must be a planner of his work. He must know how to handle men; he must know economic theory and the methods of applying to the solution of the problems that he will encounter in his work.

History, philosophy, psychology and politics have their places in an engineering curriculum. All of these subjects have a value in training the engineer of vision. Each one of these subjects plays a part in giving experiences of the past on which to predict results of the future. Each one will help in the human relations which exist in engineering in the broad sense; men as well as materials must be used by the engineer in all of his activities.—A. M. Greene, Jr., dean of School of Engineering of Princeton University.

ELWOOD HAYNES

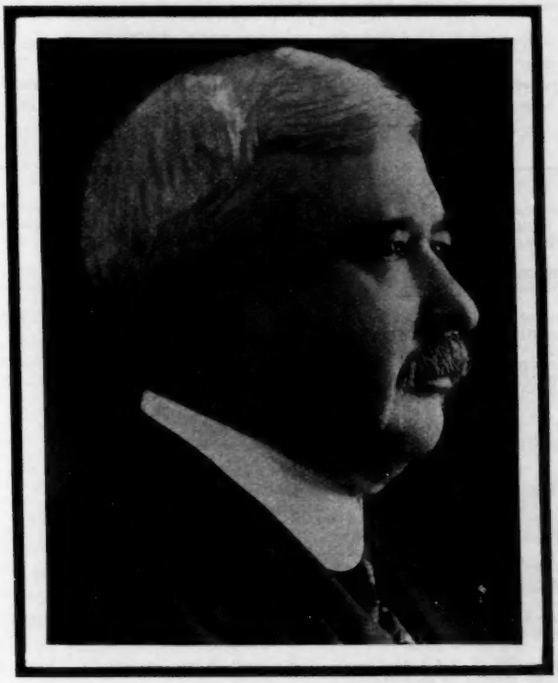
FOLLOWING a brief illness, Elwood Haynes, pioneer automobile inventor and manufacturer, died of pneumonia at his home in Kokomo, Ind., April 13. He had returned 2 weeks previously from a trip to the South that he had taken with his wife to regain his strength after an attack of influenza contracted during the winter.

Mr. Haynes, who was one of the best-known figures in the automobile industry, had been a member of the Society since 1910. Besides being the inventor and builder of one of the very first successful automobiles in America, he contributed a number of important inventions and improvements to the automobile. These included successful carbureters, mufflers, the use of aluminum in internal-combustion engine construction, and the adoption of nickel-steel and other alloys. His first successfully operated automobile is on exhibition at the Smithsonian Institution in the City of Washington.

Mr. Haynes was known internationally as a scientist and a metallurgist, as well as for his work in the automobile field. Other inventions credited to him are various alloys of cobalt, chromium, molybdenum and tungsten. The best known of these is Stellite, which is used extensively for metal-working tools and other purposes. Its discovery resulted from his search for a metallic combination that would resist the oxidizing influences of the atmosphere and still preserve a good cutting-edge.

Besides having belonged to the Society since 1910, Mr. Haynes was a member of numerous engineering and scientific societies, including the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Chemical Society and the Iron and Steel Institute. He was an ardent advocate of the use of the metric system.

At the time of his death Mr. Haynes was 67 years old, having been born on Oct. 14, 1857, at Portland, Ind. He received the degree of bachelor of science from the Worcester Polytechnic Institute in 1881 and, after teaching school for 3 years, spent a year in the study of chemistry and biology at Johns Hopkins University. For the next year he was a teacher of science at the East Indiana Normal School. Following the discovery of natural gas at his birthplace in 1886, he became manager of the Portland Natural Gas & Oil Co. From 1890 to 1901 Mr. Haynes served as field superintendent for the Indiana Natural Gas & Oil Co., making his headquarters at Kokomo. While there he became interested in gas engines and began studying the possibilities of applying the internal-combustion engine to light road-vehicles.



ELWOOD HAYNES

In 1887 Mr. Haynes was married to Miss Bertha Lanternman of Portland, Ind. Two children, a son and a daughter, assisted their father in his laboratory work in Kokomo.

JARED WARNER STARK

THE sudden death in Florida on March 24 of Jared W. Stark, president of the J. W. Stark Co. of Detroit, automobile upholstery specialists, is reported. He had left Detroit with a party of friends 3 days before to look over some land in Florida. Mr. Stark had been an Associate Member of the Society since July 29, 1912. He was born at Plymouth, Pa., on Dec. 7, 1875, received his education in the Wilkes-Barre schools and entered the commercial department of the fabrikoid works of the E. I. duPont de Nemours Powder Co. in 1911. Later he was transferred to the main office of the Company in Wilmington, Del., as special representative, and then became sales manager, which position he held until May, 1921, when he severed his connection with that organization and formed the J. W. Stark Co.

HIGHWAY AND RAIL

A GREAT increase in the use of motor cars, motorbuses and trucks is having a far-reaching effect on the short-distance railroad passenger and freight traffic and on seasonal traffic to the seaside and other resorts. The railroads have no desire to abandon a single mile of railroad, nor to reduce the service, so long as their business and the returns earned justify their retention; but when the public employs other forms of transportation facilities to meet its needs the railroads cannot afford to run unprofitable trains nor maintain stations or lines that have insufficient patronage. The situation has been further aggravated by the fact that the increased use of the highways has created demands for the abolition of grade crossings, chiefly at the expense of the railroads, and for the payment of much higher taxes to meet the increasingly heavy costs that will be incurred for highway construction and maintenance.—President Rea of Pennsylvania Railroad.

Applicants *Qualified*

The following applicants have qualified for admission to the Society between March 10 and April 10, 1925. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

ABRAM, ERNEST SAMUEL (A) technical director, Bramwood, Ltd., Hounslow, London, England, (mail) Westwood, High Lane, near *Stockport, Cheshire, England.*

ANDREW, T. M., JR. (A) treasurer, Robert H. Hassler, Inc., *Indianapolis,* (mail) 1535 Naomi Street.

BOLIN, C. H. (A) automotive engineer, Pacific Telephone & Telegraph Co., 517 Sheldon Building, *San Francisco.*

BOLKOVITINOFF, N. F. (F M) assistant in engineering department, Agricultural Academi, Moscow, Russia, (mail) Ostojenka, 1st Zachatievsky 15, 3 *Moscow, Russia.*

BUFF, CARL THEODOR (F M) betriebsdirektor, Deutsche Werke Aktiengesellschaft, *Spandau, Germany.*

BUREN, NEWTON J. (A) manager, Tsungani Piston Co., *Tacoma, Wash.,* (mail) 625 East 11th Street.

BURGEY, FIRST-LIEUT. SAMUEL S. (A) Ordnance Department, *Fort Totten, N. Y.*

CROMLEY, W. W. (M) assistant general manager, Sterns Motor Mfg. Co., *Ludington, Mich.*

DE GANAHL, CARL (J) works manager, Medway Oil & Storage Co., Ltd., *Isle of Grain, Kent, England.*

DONKIN, W. T. (A) engineer, Cleveland Wire Spring Co., 1281 East 38th Street, *Cleveland.*

DUBOIS, RALPH N. (S M) assistant mechanical engineer, Bureau of Standards, *City of Washington.*

EARNSHAW, WILLIAM B. (M) head of dynamics research section, General Motors Research Corporation, *Dayton, Ohio,* (mail) 10 Sawmill Road.

ENDERS, EGBERT E. (A) road service representative, service department, Olds Motor Works, Lansing, Mich., (mail) c/o Olds Motor Works, 2500 Commerce Street, *Dallas, Tex.*

FABIAN, JULES (M) designer, General Motors Research Corporation, *Dayton, Ohio,* (mail) 2337 Parkland Avenue.

FEELY, J. H. (A) salesman, Autocar Sales & Service Co., 553 West 23rd Street, *New York City.*

FELDMAN, WILLIAM (A) city sales and service-manager, Detroit Branch, American Bosch Magneto Corporation, *Detroit,* (mail) 5737 Pennsylvania Avenue.

FOLBERTH, FRED G. (M) president, Folberth Auto Specialty Co., 7914 Lake Avenue, *Cleveland.*

GEPHART, VALENTINE (A) technical service and sales, Octo Co., *Seattle, Wash.,* (mail) 205 Summit Street North.

GLASNER, R. W. (A) president, Marquette Tool & Mfg. Co., 319 West Ohio Street, *Chicago.*

GRIMES, CHARLES F. (A) foreman of testing, repair department, Chevrolet Motor Co., *Janesville, Wis.,* (mail) 850 Sherman Avenue.

HENRICHSEN, KNUT (J) draftsman, Huff, Daland & Co., *Ogdensburg, N. Y.*

HESSLER, J. A. (A) secretary and sales manager, Western Felt Works, 4115 Ogden Avenue, *Chicago.*

KARMAZIN, JOHN (M) manager in charge of production, Flintlock Corporation, 2065 West Lafayette Boulevard, *Detroit.*

LAMB, F. R. (M) methods and standardization department, Studebaker Corporation of American, R. F. D. No. 2, *Redford, Mich.*

LIVERMORE, HARVEY J. (A) engineer, National Lead Battery Co., 1704 Roblyn Avenue, *St. Paul, Minn.*

LORMOR, H. W. (A) equipment manager, Willard Storage Battery Co., East 131st Street, *Cleveland.*

MCCLOSKEY, L. T. (A) vice-president and Western manager Diamond State Fibre Co., 1656 Besley Court, *Chicago.*

MILLS, JOHN W. (F M) managing director, Halley's Industrial Motors, Ltd., Yoker, Glasgow, Scotland, (mail) Glenrosa Victoria Park Drive North, *Scotstoun, Glasgow, Scotland.*

MINICH, HENRY D. (A) consulting engineer, Greyledge, R. F. D. No. 3, *Troy, N. Y.*

MITTEN, RAYMOND FLOYD (A) field engineer, Automotive Maintenance Machine Co., Chicago, (mail) Akron Hotel, *Akron, Ohio.*

QUACKENBUSH, F. A. (A) manager, Cudahy Packing Co., *Chicago,* (mail) 9022 Baltimore Avenue.

RAGSDALE, W. H. (J) Carnegie Institute of Technology, *Pittsburgh, Pa.*

REID, PERCY H. (A) service-manager, Benson-Manley, Ltd., *Montreal West, Que., Canada,* (mail) 118 Strathern Avenue.

REID, VAUGHAN (A) president and manager, City Pattern Works, *Detroit,* (mail) 2270 Edison Avenue.

SHORT, MAC (J) aeronautical engineer, aeronautical engineering department, Massachusetts Institute of Technology, *Cambridge, Mass.*

SLOAN, JOHN A. (J) foreman, International Motor Co., 252 West 64th Street, *New York City.*

SPONDER, HARRY K. (M) chief draftsman, Lang Body Co., *Cleveland,* (mail) 2311 Broadview Road.

WARD, AARON (J) miniature lamp department, Westinghouse Lamp Co., 150 Broadway, *New York City.*

WATERBURY, W. E. (A) superintendent, Timken Detroit Axle Co., Waterloo Avenue plant, *Detroit.*

WERNER, CLARENCE H. (A) service-manager, Apperson Automobile Co., *Kokomo, Ind.,* (mail) 1017 East Walnut Street.

WINSLOW, CHARLES A. (M) engineer, Winslow Mfg. Co., Vallejo, Cal., (mail) 116 West Anne Street, *Flint, Mich.*

Applicants *for* Membership

The applications for membership received between March 14 and April 15, 1925, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ADAMS, LYMAN D., general manager, Barnes-Gibson-Raymond, Inc., *Detroit.*

ANDERSON, ROY F., chief engineer, Hayes-Ionia Co., *Grand Rapids, Mich.*

BENTZ, ROBERT JOHN, service organization work, Ajax Motors Co., *Racine, Wis.*

BRACKETT, FRANK J., field engineer, General Motors Corporation, 224 West 57th Street, *New York City.*

BRADLEY, VOLNEY E., salesman, H. C. S. Smith, *San Antonio, Tex.*

BREHM, PAUL H., service-manager, Fageol Motors Co. of Ohio, *Kent, Ohio.*

BUCKNEY, E. J. D., designer, Guy Motors, Ltd., *Wolverhampton, England.*

BUQUOR, JOHN LEO, automobile investigator, City of El Paso, *El Paso, Tex.*

BURGER, F. A., foreman, Armour & Co., *San Francisco.*

CARLISLE, ROBERT JOHN, garage manager, Valley Transit Co., Inc., *Fresno, Cal.*

CATTANEO, GIUSTINO, general technical manager, Fabrica Automobili Isotta-Frischini, *Milan* (37), *Italy.*

CHAMBERS, G. DUDLEY, mechanical draftsman, Willys-Overland Co., Inc., *Toledo.*

COLLINS, FIRST-LIEUT. LAWRENCE C., regimental motor transport officer, Fort Williams, *Portland, Me.*

DAVIS, ALFRED C., vice-president and general manager, Marlin-Rockwell Corporation, 402 Chandler Street, *Jamestown, N. Y.*

DIETZ, RUDOLPH ARTHUR, branch manager, E. B. Atmus Co., Inc., *Boston.*

EAGLE, HENRY, president, Chadwick, Delamater Corporation, *New York City.*

EASTON, EDMOND C., chief engineer, California Carburetor Co., Inc., *San Francisco.*

EATON, B. H., motor-vehicle inspector, Bell Telephone Co .of Pennsylvania, *Scranton, Pa.*

EDWARDS, OLIVER D., local representative, Mack-International Motor Truck Corporation, *City of Washington.*

EISENMAN, W. H., national secretary, American Society for Steel Treating, *Cleveland.*

EQUITABLE AUTO CO., *Pittsburgh.*

FENNER, ARTHUR F., vice-president and division manager, Mack-International Motor Truck Corporation, *New York City.*

FENNER, HERBERT E., service manager, American Bosch Magneto Corporation, *Springfield, Mass.*

FITZJOHN, H. A., president and general manager, FitzJohn Mfg. Co., *Muskegon, Mich.*

FORD, EDSEL B., automobile manufacturer, Ford Motor Co., *Detroit.*

FULLER, HENRY J., chairman of the board of directors, Rolls-Royce of America, Inc., *Springfield, Mass.*

GARNER, H. H., president, Vortox Mfg. Co., *Pomona, Cal.*

GARRETSON, DONALD C., service-manager, Garretson Co., *Perth Amboy, N. J.*

GENERAUX, GARFIELD D., shop superintendent, Gilmore Oil Co., *Los Angeles.*

GIFFORD, CLAYTON E., engineer, Huber Mfg Co., *Marion, Ohio.*

GOUDARD, MAURICE, Societe Anonyme Solex, 190 Avenue de Neuilly, *Neuilly-sur-Seine, France.*

GRAFF, GEORGE W., sales engineer, Manley Mfg. Co., *York, Pa.*

GRAVES, CULLEN P., branch manager, Mack-International Motor Truck Corporation, *Duluth, Minn.*

GREENWOOD, R. C., mechanical engineer, Philbrin Corporation, *Kennett Square, Pa.*

GUSTAFSON, WALTER A., assistant engineer, New England Telephone & Telegraph Co., *Dorchester, Mass.*

HERZOG, W. F., special representative, Studebaker Corporation of American, *South Bend, Ind.*

HIRSCHLER, HORACE L., chief engineer, Horace Remote Control Co., Steuart Street, *San Francisco.*

HOLM, R. M., sales promoter of automotive oils, Standard Oil Co., *Duluth, Minn.*

KATZ, ARTHUR, designing draftsman, 300 Haven Avenue, *New York City.*

KENNEDY, MAJOR FRANK M., Air Service, McCook Field, *Dayton, Ohio.*

KINSMAN, C. D., senior agricultural engineer, Department of Agriculture, *City of Washington.*

KNOPF, C. L., lubrication engineer, Sinclair Refining Co., *Chicago.*

KREBS, R. M., compiling parts books, service department, Graham Bros., *Detroit.*

LEE, CHARLES L., head of semi-works engineering division, General Motors Research Corporation, *Dayton, Ohio.*

LIENHARD, GABRIEL, chief engineer, Rhemg, *Berlin-Weissensee, Germany.*

LILJEROTH, STURE HERBERT, engineer, International Motor Co., *New York City.*

LINDSAY, WILLIAM H., commissioner, Department of Justice and National Park Service, *Belton, Mont.*

LINK, VINCENT, consulting engineer, Studebaker Corporation of America, *Detroit.*

LOCHRIDGE, L. P., manager of domestic lubricating sales department, Sinclair Refining Co., 45 Nassau Street, *New York City.*

LOWEKE, ERWIN F., draftsman, Timken-Detroit Axle Co., *Detroit.*

MELOCHE, DANIEL H., metallurgist, Holley Carburetor Co., *Detroit.*

MEYER, ANDRE J., draftsman, Continental Motors Corporation, *Detroit.*

MICHELL, WILLIAM PEARSE, engineer, International Motor Co., *Allentown, Pa.*

MOON, JOHN ALEXANDER, tool engineer, Rolls-Royce of America, Inc., *East Springfield, Mass.*

MUELLER, PAUL M., engineer, Pratt & Whitney Co., *Hartford, Conn.*

MURRAY, WILLIAM THOMAS, truck-building, H. M. Patterson & Son, *Atlanta, Ga.*

NEVILLE, CHARLES A., general manager, Transport Equipment Corporation, *Los Angeles, Cal.*

NEY, ALFRED M., designer and builder of racing cars, European Motors Service, 221 West 64th Street, *New York City.*

ORELUP, J. W., research director, Chemical Co. of America, *Springfield, N. J.*

OSTHEIMER, JOHN W., Societe Anonyme Solex and Compagnie Franco Americaine des Jantes en Bois 190 Avenue de Neuilly, *Neuilly-sur-Seine, France.*

PILLING, ROBERT, draftsman, J. G. Brill Co., *Philadelphia.*

POLLARD, ROBERT W., sales engineer and purchasing agent, Columbia Axle Co., 850 East 72nd Street, *Cleveland.*

PRIOR, LELAND S., JR., mechanical superintendent, O. W. Hahn Co., *San Francisco.*

RAUEN, JOHN B., general manager, secretary and treasurer, U. S. Spring Co., Inc., and secretary and treasurer, U. S. Bumper Co., Inc., *Los Angeles.*

REDBURN, A. R., superintendent of transportation, Alabama Power Co., *Birmingham, Ala.*

RIBLET, R. M., chief draftsman, Timken Roller Bearing Co., *Canton, Ohio.*

RITTER, HARRY E., president, Mid-West Glass Co., 2235 Buck Street, *Cincinnati.*

ROMER, ALBERT J., chief engineer, Royal Motor Car Co., *Newark, N. J.*

ROOS, WILLIAM A., JR., boat construction, transportation and sales, Consolidated Shipbuilding Corporation, *New York City.*

RYAN, THOMAS M., designing engineer, Flint Motor Co., *Flint, Mich.*

SANTOMENO, M. A., automobile mechanic, F. W. Williams, *Hartford, Conn.*

SAUERBREY, P. C., general superintendent, Muncie Products Division of General Motors Corporation, *Muncie, Ind.*

SAURER, CURT, chief engineer of automotive development, U. S. Rubber Co., *Cleveland.*

SCHERMERHORN, J. R., student, Ohio Northern University, *Ada, Ohio.*

SCHMIT, A. M., chief inspector in charge of factory service-men, Electric Auto-Lite Corporation, *Toledo.*

SELZER, JOHN, foreman of the experimental department, International Harvester Co., *Fort Wayne, Ind.*

SNEAD, ARTHUR R., State service-manager, Mack International Motor Truck Corporation, *Dallas, Tex.*

SPENCER, ROLAND L., engineer, Vacuum Oil Co., *New York City.*

STANLEY, C. R., automotive inspector, Pacific Gas & Electric Co., *San Francisco.*

STONER, EMORY W., sales engineer and advertising manager, Haskelite Mfg. Co., *Chicago.*

TAYLOR, CLIFTON, sales manager, Molybdenum Corporation of America, *Pittsburgh.*

TINKHAM, CARL C., master mechanic, Hallach & Howard Lumber Co., *Denver.*

TORRACA, LOUIS A., district engineer, Socony Burner Corporation, *Brooklyn, N. Y.*

TOWLE, URBAN A., proprietor, Towles Garage, *Portland, Me.*

VOEGELI, ALBERT, mechanical engineer and tool designer, C. J. Tagliabue Mfg. Co., *Brooklyn, N. Y.*

WATSON, HARVEY L., engineering manager of automotive division, Hyatt Roller Bearing Co., General Motors Building, *Detroit.*

WHITE, THOMAS M., production manager, A. B. C. Trailer Truck Co., *Memphis, Tenn.*

WYRICK, CLAYTON E., mechanical engineer and patent attorney, Clayton E. Wyrick, *Detroit.*